LISTEN. THINK. SOLVE.®

T60 - Integrated Safety with Kinetix® and PowerFlex® drives

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Allen-Bradley • Rockwell Software

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Agenda

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- Introduction
- Machine Safety Lifecycle
- Motor Safety
- Drive Safety
- Tools & Services

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Definition of Safety

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Safety

Freedom from unacceptable risk

Functional Safety

Part of the safety of the machine and the machine control system which depends on the correct functioning of:

- the safety related electrical control system
- other technology safety-related systems
- external risk reduction facilities

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Evolution of Safety

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As our relationship to machines has changed, so has society's emphasis for machine safety

Properly designed safety never needs to be bypassed!

Lock-Out Tag-Out is still relevant, but alternative methods can boost production without compromising safety

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Machine Safety Lifecycle

Organizations, Standards & Guidelines

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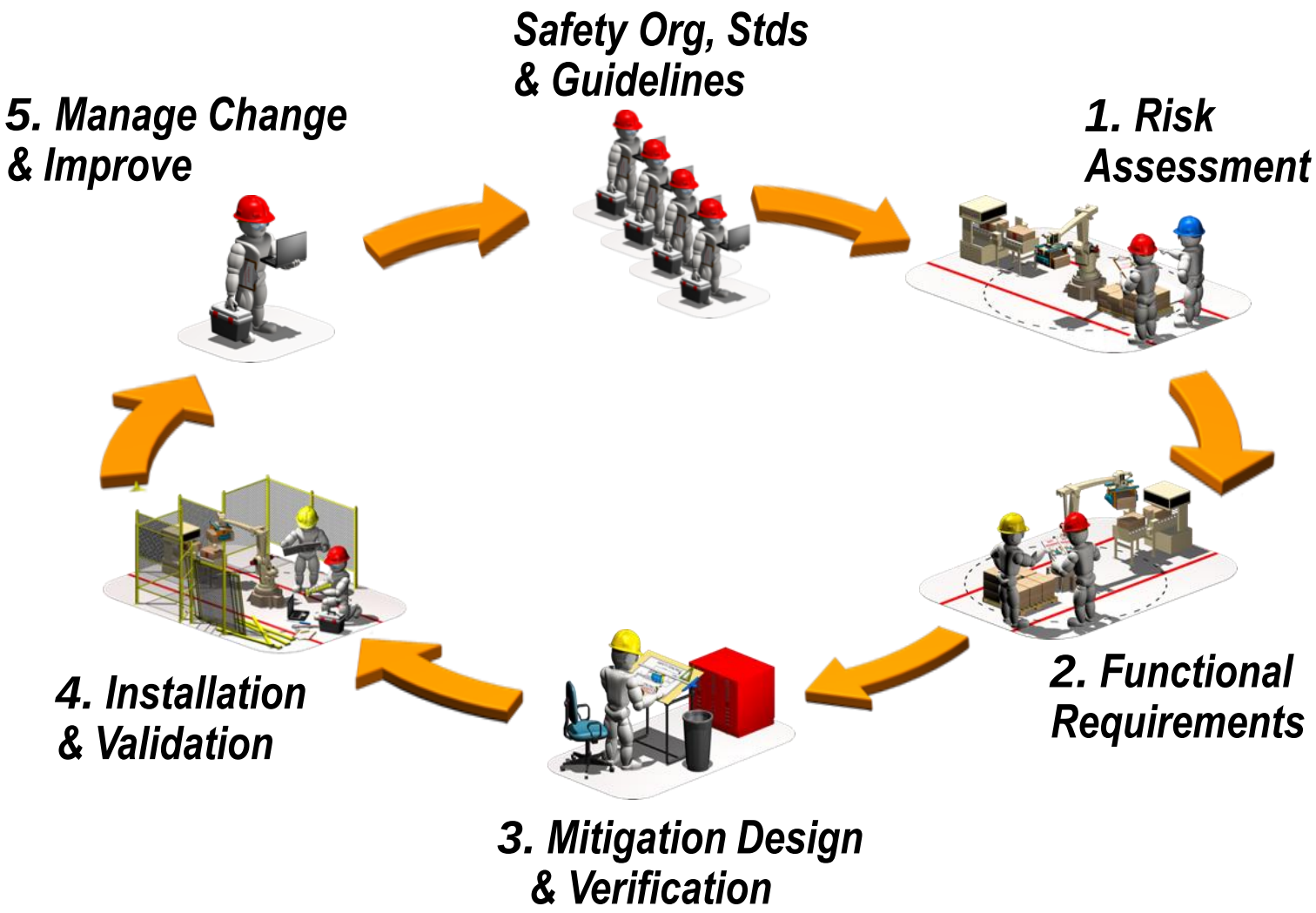
Safety Org, Stds & Guidelines
1. Risk Assessment
2. Functional Requirements
3. Mitigation Design & Verification
4. Installation & Validation
5. Manage Change & Improve

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Safety Organizations

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Which Standards Apply?

Geographic Constraints

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- Where are you, and where will the machine / system be located?
  - If you are an OEM, be sure you ask your customer if they have any corporate safety requirements
  - For the US - You must meet OSHA requirements
    - OSHA recognizes consensus standards
    - NFPA 79, ANSI Z244.1, etc.
  - Internationally – Use ISO and IEC standards
- Good news!
  - Most NFPA and ANSI standards can be related back to ISO and IEC standards
  - Strong safety circuit design is consistent through all of the standards, though the terminology changes

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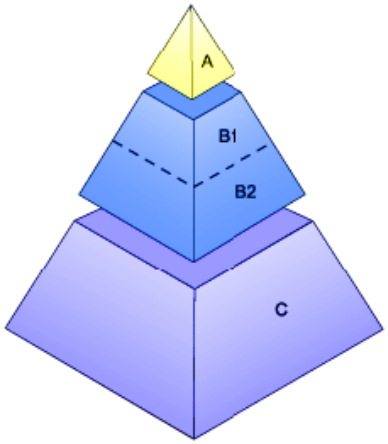
Organization of Standards

Three-tier Structure of International Safety Standards



Type A Fundamental safety standards applicable to all machinery. Type A standards deal with basic concepts, principles for design, and general aspects.

Type B Standards applicable to a wide range of machinery. Type B is divided into two catagories:

B1: Specific safety aspects (ie., safety distance, surface temperature, and noise)
B2: Safety related devices (ie., two-hand controls, interlocking devices, pressure sensitive devices, and guards)

Type C Detailed standards applicable to a specific machine or a particular group of machines.

Type A - Basic Safety Standards		
	Standard for basic design concepts	ISO12100-01,-2
	Standard for risk assesment	ISO14121
Type B - Machinery Standards		
B1	Standard for safe distance	ISO13852 (EN294)
	Standard for basic principles for human ergonomics	(EN614)
	Standard for conrtol system	ISO/JIS13849-(EN954-1)
B2	Standard for emergency stop	ISO13850 (EN418)
	Standard for two-hand control system	ISO/JIS13851 (EN574)
	Standard for card interlock	ISO14119 (EN1088)
	Standard for electrical equipment of machine	IEC60204-1
	Standard for switches	IEC60947 (EN60947)
	Standard for explosion proof equipment	IEC60079
	Standard for EMC Sensor	IEC6100
	Standard format sensor	ISO13856
Type C - Product Specific Standards		
	Standard for machine press	(prEN692)
	Standard for injection system	(EN201)
	Standard for industrial robot	ISO10218 (EN775)

- All functional safety standards are used to demonstrate compliance to global, regional and sometimes, national legal requirements
- Three types of Standards
  - "A" Standards
    - basic concepts
    - principles for design
    - general aspects
  - "B" Standards
    - B1 - safety distances, surface temps, noise
    - B2 - components or devices
  - "C" Standards
    - vertical standards covering a single type of machine or group of machines.
    - Use A and B standards to create C standards.

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Type A & Type B Standards

North America

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ANSI B11.0

General Requirements and Risk Assessment

ANSI B11.19

Performance Criteria for Safeguarding

- These two standards can get you most of the way with most safety applications in North America
- These are not recognized **by** the international community
- These standards **do** recognize the international community

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Type A & Type B Standards

International

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ISO 12100

Safety of Machinery – General Principles for Design –
Risk Assessment and Risk Reduction

ISO 13849-1

Safety of Machinery – Safety Related Parts of Control Systems
Part 1: General Principles for Design

- Replaced EN 954 in 2008
- Simple devices, including electromechanical devices
- Common Terms:
  - Categories (structure), Diagnostic Coverage (DC), Performance Levels (PL), Probability of Dangerous Failure per Hour (PFH_D)

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Going Between Standards

ANSI B11.19 & ISO 13849-1

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While the requirements of control reliability are not directly comparable to the requirements of ISO 13849-1 (1999) or EN/ISO 13849-1 (2008), for the purposes of this standard, complying with Category 3 or 4 and/or Performance Level —d or —e, at a minimum, will satisfy the requirements of control reliability.

Other Categories and Performance Levels per EN/ISO 13849-1, and Safety Integrity Levels (SILs) per IEC 61508 and IEC 62061 can also satisfy the requirements of this sub-clause depending on the design, construction, fault exclusions, installation, and maintenance of the safety-related function and a documented risk assessment.

Right out of ANSI B11.19, E6.1

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Summary of Standards

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- Standards are there to help you by taking the guesswork out of your safety system design
- Use Type C standards when you can, otherwise use Type A & Type B
- Don't be afraid to ask for help to understand them
  - There are a lot of good interpretations online
- My recommended "desert island" standards:
  - ANSI B11.0 / ANSI B11.TR3 or ISO 12100
  - ANSI B11.19
  - ISO 13849-1 & -2
  - IEC 60204-1 or NFPA 79

Use the standards to your advantage!

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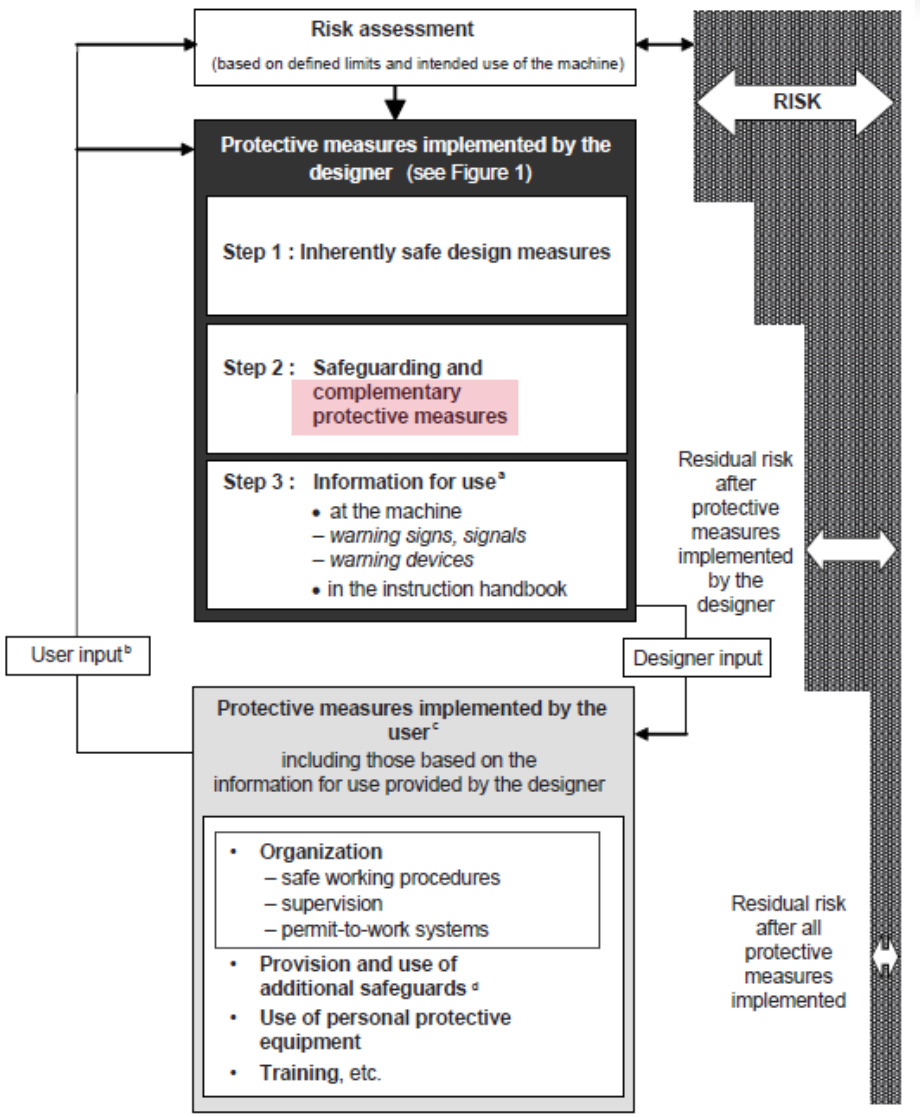
Principles of Risk Assessments

Risk Reduction

- Hierarchy of Protective Measures
  - Inherently safe design
  - Fixed guards
  - Complementary protective measures
  - Awareness (signs, signals, user manual)
  - Personal protective equipment
- Some can be implemented by the machine builder
- Some rely on the end user's organization


Risk assessment
(based on defined limits and intended use of the machine)
RISK
Protective measures implemented by the designer (see Figure 1)
Step 1 : Inherently safe design measures
Step 2 : Safeguarding and complementary protective measures
Step 3 : Information for use[a]
• at the machine
– warning signs, signals
– warning devices
• in the instruction handbook
Residual risk after protective measures implemented by the designer
User input[b]
Designer input
Protective measures implemented by the user[c]
including those based on the information for use provided by the designer
• Organization
– safe working procedures
– supervision
– permit-to-work systems
• Provision and use of additional safeguards[d]
• Use of personal protective equipment
• Training, etc.
Residual risk after all protective measures implemented

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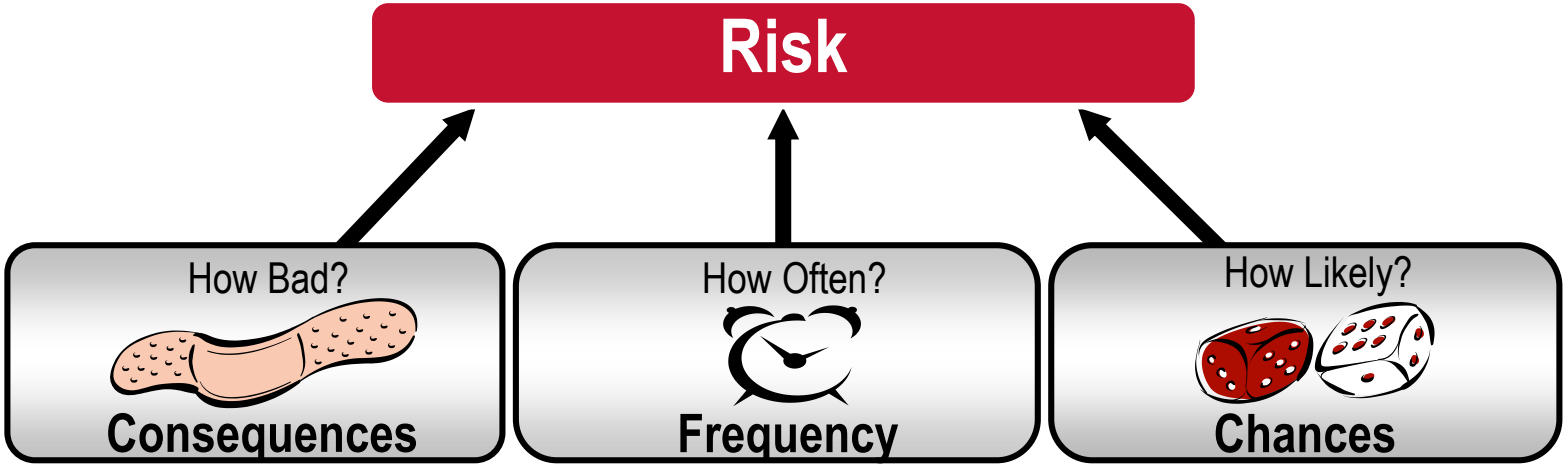
Performing Risk Assessments



- Important to remember:
  - What is the operating mode?
  - Who is interacting with the machine?
  - When in the lifecycle is this activity?
  - What has already been done for protection?

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Functional Requirements

Basic Concepts

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- Functional Safety Specifications outline how a safety system responds from system inputs to control system outputs
- Functional safety specifications should address the following items:
  - All modes of operation (Auto/Manual/Jog)
  - All machine interactions (Jam removal/Cleaning/Set-up/Adjustment)
  - Speed control and monitoring (Safe-speed/Safe-stop/etc.)
  - Drive control (Braking/Accel/Decel)
  - Special safety functions (Blanking/Muting/Zone Control)

Keep them as simple as possible!

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Functional Requirements

Basic Concepts

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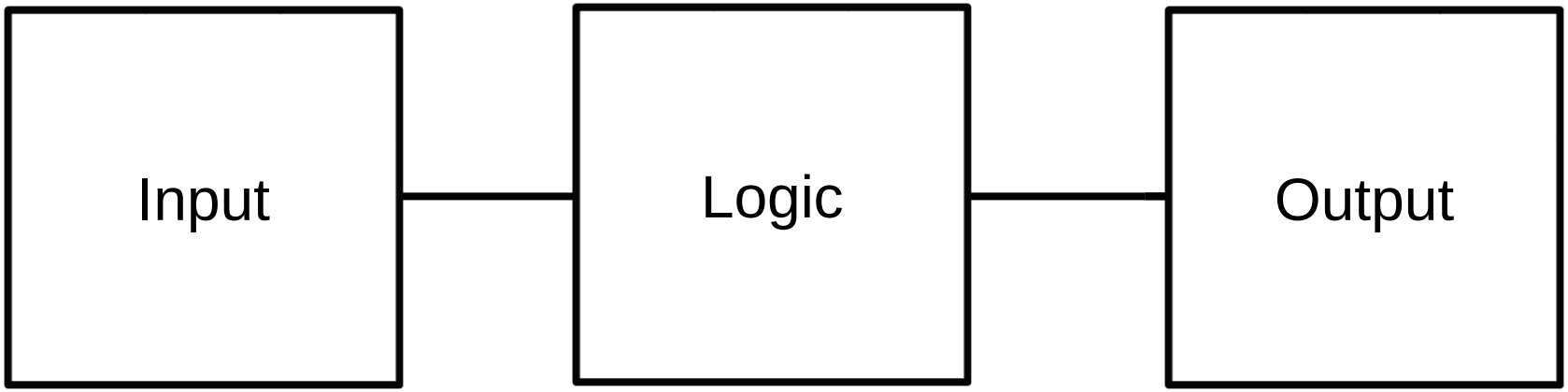
- Safety functions should always be written as
  - Input – Interlocks, Sensors, E-stops, Light Curtains
  - Logic – Safety Logic Relays, Safety Controllers
  - Output – Contactors, Drives
- Below is an example of a simple Functional Safety System using a simple door interlock, a safety relay and safety contactors



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Mitigation Design & Verification

Basic Concepts

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- Mitigation Design
  - Which products are used
  - How components are wired
  - Where they are placed on the machine
  - Code is written
- Verification
  - Determine if the implementation meets the requirements
  - Perform PL or SIL calculations at this time
  - SISTEMA can be used when ISO 13849-1 is the standard to verify

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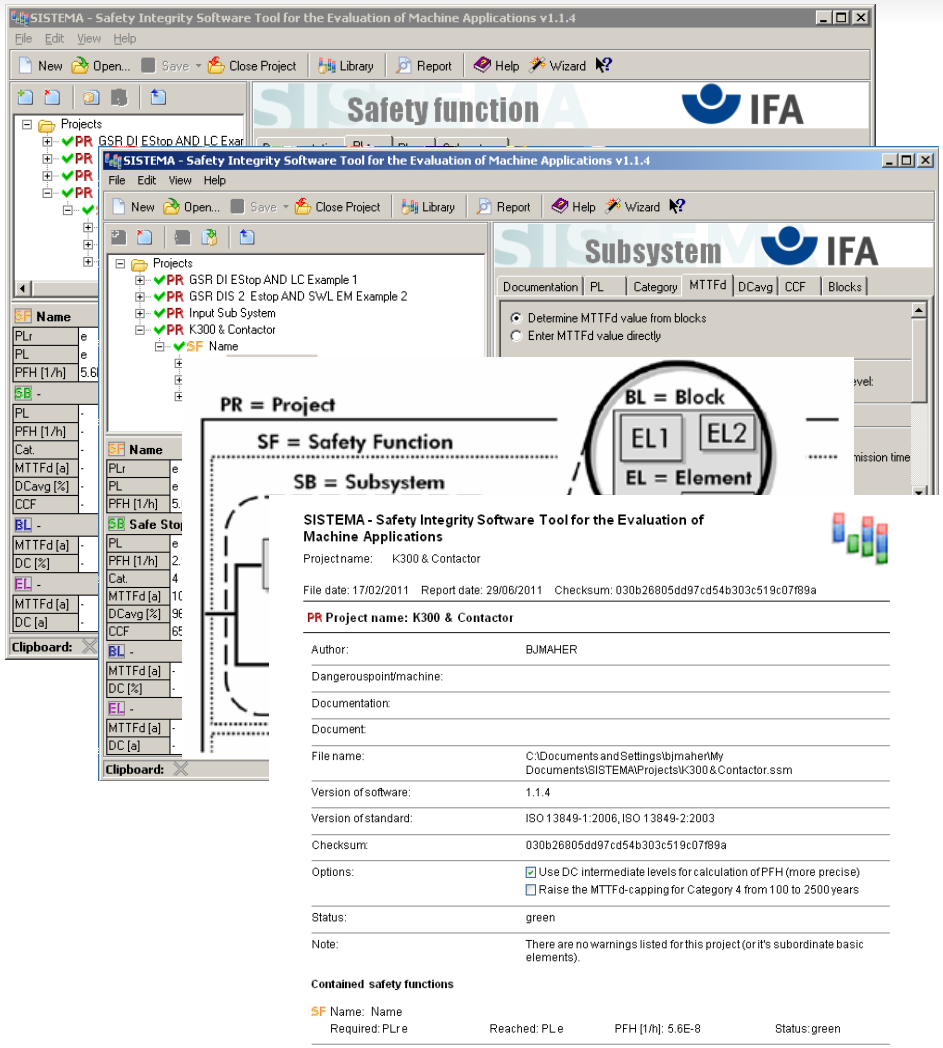
Mitigation Design & Verification

SISTEMA for ISO 13849-1

- Developed and maintained by a neutral and well-respected organization specializing in Functional Safety
- Simplified entry of safety related reliability information
- Vendor libraries reduce work to find critical data
- Reduce risk of mistakes in calculations
- Graphical view of safety functions
- Automatic report generation for faster documentation



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Installation & Validation

Basic Concepts

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- Follow through with the Mitigation Design
- Induce faults to validate system
- Use ISO 13849-2 for techniques, such as Table D.9 shown below

Fault considered	Fault exclusion	Remarks
All contacts remain in the energized position when the coil is de-energized (e.g. due to mechanical fault)	None.	—
All contacts remain in the de-energized position when power is applied (e.g. due to mechanical fault, open circuit of coil)	None.	
Contact will not open	None.	
Contact will not close	None.	
Simultaneous short circuit between the three terminals of a change-over contact	Simultaneous short circuit can be excluded if remarks are taken into account.	The creepage and clearance distances are dimensioned to at least IEC 60664-1 with at least pollution degree 2/overvoltage category III. Conductive parts which become loose cannot bridge the insulation between contacts and the coil.
Short circuit between two pairs of contacts and/or between contacts and coil terminal	Short circuit can be excluded if remarks are taken into account.	
Simultaneous closing of normally open and normally closed contacts	Simultaneous closing of contacts can be excluded if remark is taken into account.	Positively driven (or mechanically linked) contacts are used (see IEC 60947-5-1:2003, Annex L).

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Manage Change & Improve

Basic Concepts

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OEMs

- Maintain designs to latest standards
- Perform Risk Assessments whenever designs are improved
- Add value through documentation
- Look for feedback from customers

End Users

- Maintain designs to latest standards
- Perform Risk Assessments whenever designs are improved
- Expect documentation from OEMs
- Thoroughly document any changes from original machines
- Provide feedback to OEMs and governing bodies

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Machine Safety Lifecycle

Organizations, Standards & Guidelines

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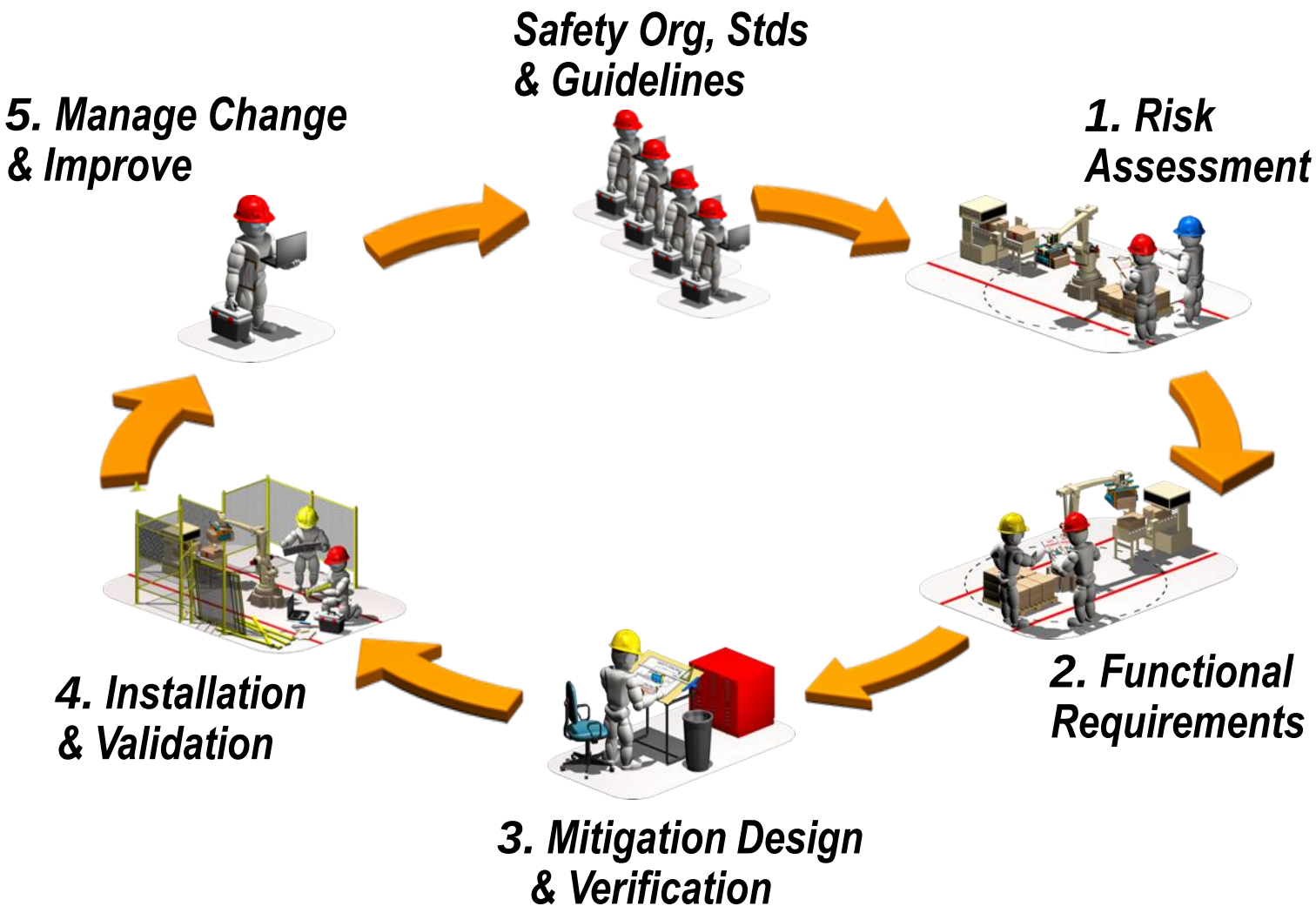
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- Machine Safety Lifecycle
- **Motor / Drive Safety**
- Drive Safety
- Tools & Services

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AC Motor Safety

Basic Concepts and Contactors

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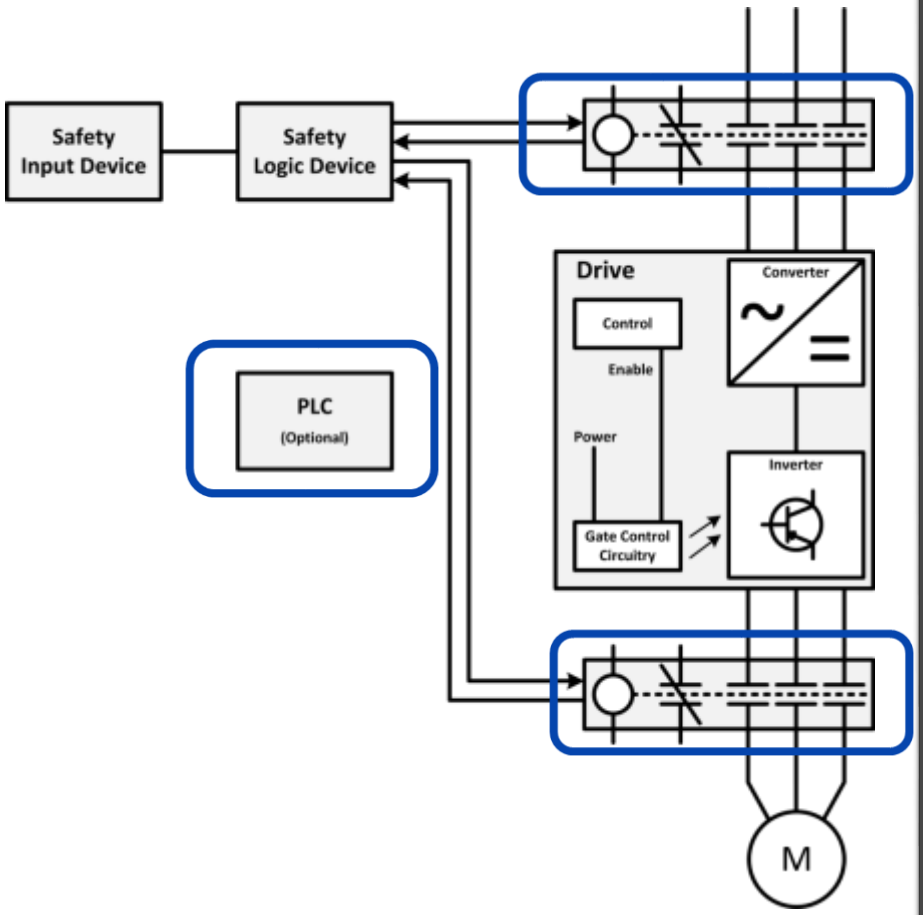
- Motors create some of the most common hazards on a machine
- Removal of torque producing power is the **only** method of safe control for motors
- Dual contactors are the traditional method for safe removal of motor power
  - Contactors must be oversized to increase life and reduce chances of welding
  - Lots of additional wiring



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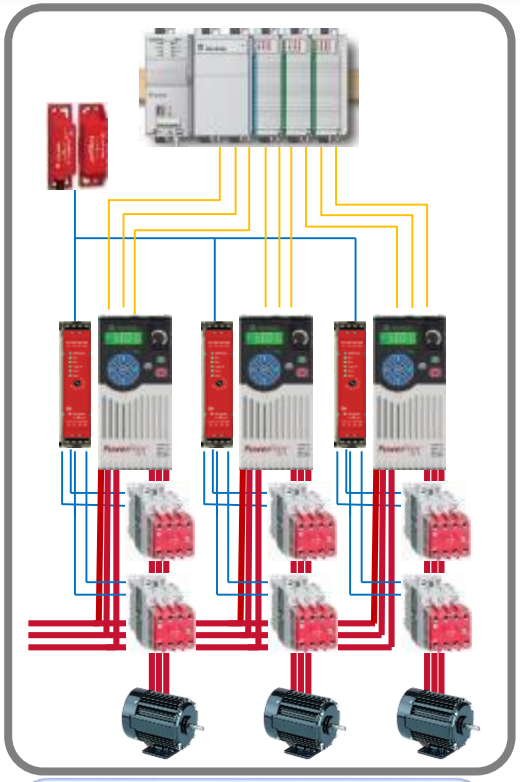
Drive Safety - External Safe Torque-off



Power wiring - $$$
Control wiring - $$$
Labor - $$$

- Maximum amount of panel space required
  - Multiple output contactors required for Cat 3 & 4
- Maximum amount of installation/down time
  - Tedious wiring
  - Work increases with desired Category level
  - Contactor welding may occur
- Lowest level of system reliability
- No Diagnostics
- Equipment required:
  - 1769-L30ER CompactLogix™ 1 MB EtherNet/IP Controller
  - 1769-IQ16 CompactLogix™ 16 Pt 24VDC D/I Module
  - 1769-OB8 CompactLogix™ 8 Pt 24VDC D/O Module
  - 1769-OF4VI CompactLogix™ 4 Pt A/O VoltageModule
  - (3) 25A-D6P0N104 3HP PowerFlex® 523 AC Drive
  - (6) 100S-C12D14BC 12 A Safety Contactor
  - (3) 440R-D22R2 Guardmaster® Dual Input Safety Relay
  - 30 control terminations for contactors, 4 safety input terminations, 18 I/O terminations for drives at $25/termination
  - 36 extra power terminations for contactors

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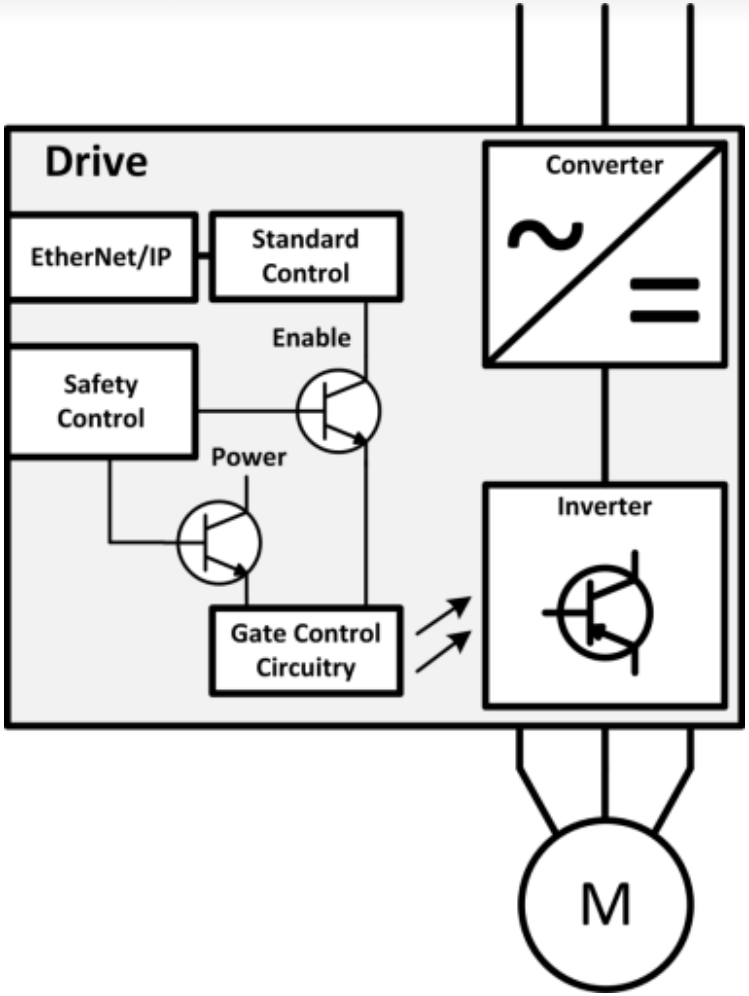
Drive Safety - Safe Torque-off

- Remove torque by preventing the Inverter from synchronized switching
- Gate Control Circuitry creates waveforms to Inverter
- By disabling the Gate Control Circuitry, the Inverter cannot create torque at the motor
- Safety Control removes signals to Enable and Power of the Gate Control Circuitry
- Components have excellent reliability in a dual channel configuration



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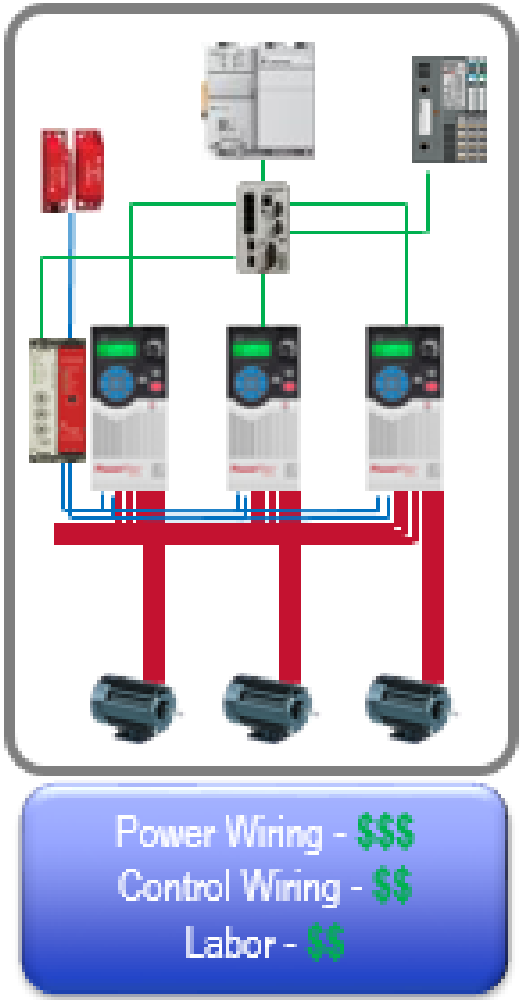
Drive Safety – Hardwired Safe Torque-off



- Low level of panel space required
- Diagnostics: Basic fault information – Drive detects something is wrong, 440R also reports faults in components but reasons for safety demand require further investigation.
- Moderate amount of installation time
- Significantly improved level of reliability
  - No contactors required
  - Fewer opportunities for installation error
- Equipment required:
  - 1769-L30ER CompactLogix™ 1 MB EtherNet/IP Controller
  - (3) 25B-D6P0N104 PowerFlex® 525 AC Drives
  - 1783 – BMS06SL Stratix™ 5700 6 Port Managed Switch
  - 1734-AENTR POINT I/O™ Dual Port Network Adaptor
  - 1734-IB8 24V DC 8 Channel Sink Input Module
  - 1734-OB4 24V DC 4 Channel Source Output Module
  - 440R-ENETR GSR Ethernet Interface
  - 440R-D22R2 Guardmaster® Dual Input Safety Relay
  - 8 safety terminations/4 safety input terminations at $25/termination

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Drive Safety Functions

Safe Torque-off – Hardwired vs Integrated

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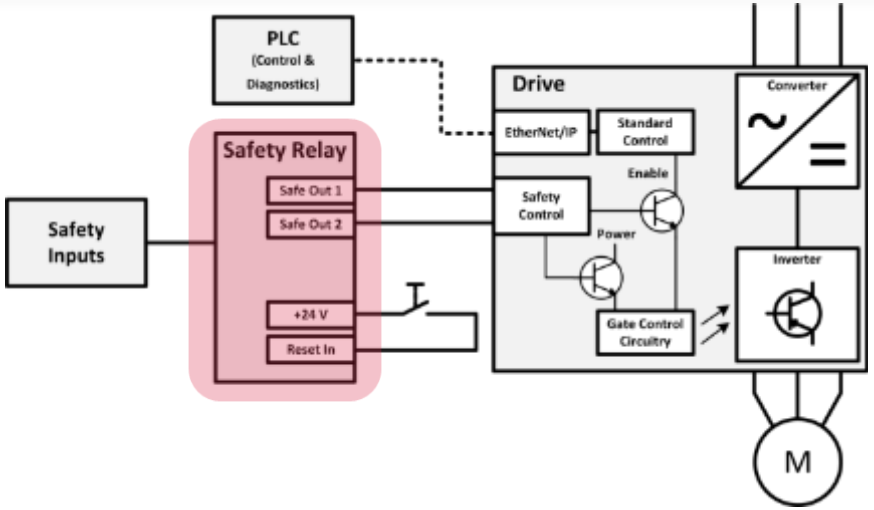
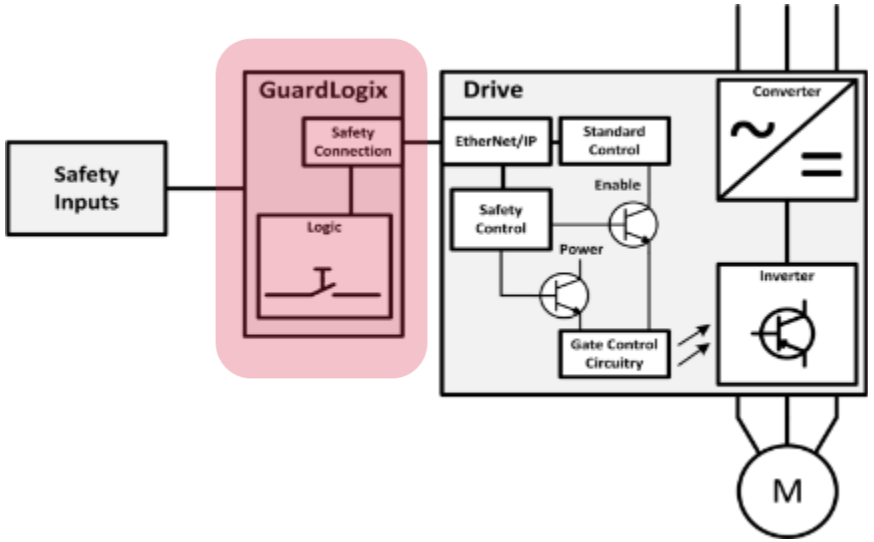
Hardwired Safety

- Drive based monitoring
- Safety relay for input devices
- Discrete safety wiring



Integrated Safety

- Controller based monitoring
- Guard Point I/O input devices
- Communication via EtherNet/IP



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Drive Safety – Integrated Safe Torque-off

- Advanced level of diagnostics: Specific information on what component faulted / experienced safety demand and why
- Lowest level of panel space required
  - No contactors
  - No safety relays
- Lowest amount of installation time
  - No bothering with small terminals
  - Fewer user manuals to read
  - Low opportunity for wiring error
- Highest level of reliability
  - Only EtherNet/IP cable required
- Equipment required:
  - 1769-L30ERMS Compact GuardLogix® Controller
  - (3) 25C-D6P0N104 3HP PowerFlex® 527 AC Drive
  - 1734-AENTR POINT I/O™ Dual Port Network Adaptor
  - 1734-IB8S 8 Channel Safety Sinking Input Module
  - 1734-IB8 24V DC 8 Channel Sink Input Module
  - 1734-OB4 24V DC 4 Channel Source Output Module

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Drive Safety Functions

Integrated Safe Torque-off

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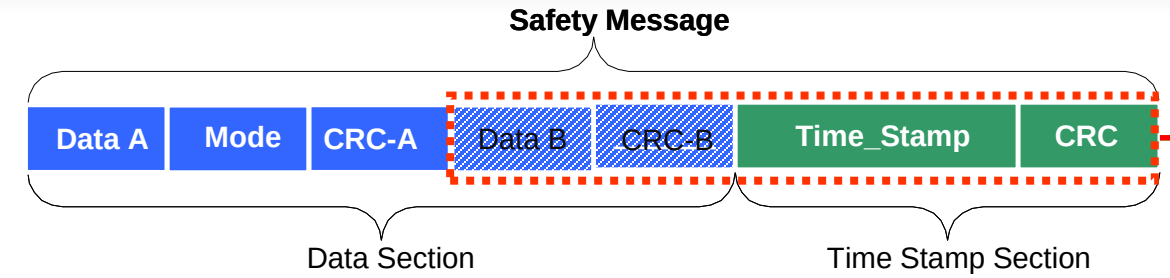
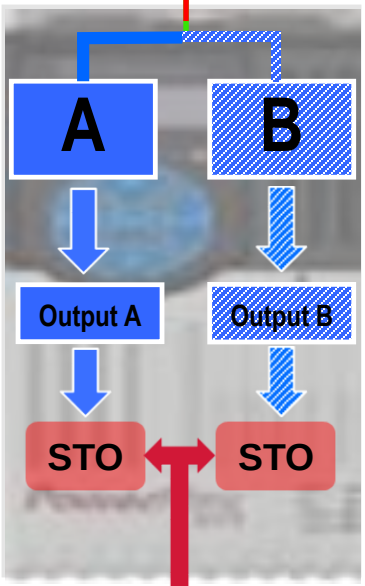


Producer to Consumer



Normal data

Inverted data

> Duality
> Diagnostics
> Diversity

- Capable of SIL3 / PLe
- Independent of network media
  - Wired and wireless
- Works across many different networks

EtherNet/IP CIP Safety Packet provides Duality, Diagnostics and Diversity!

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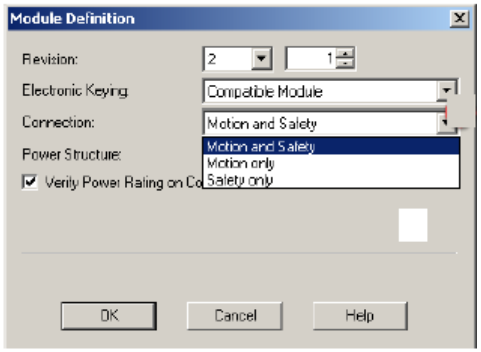
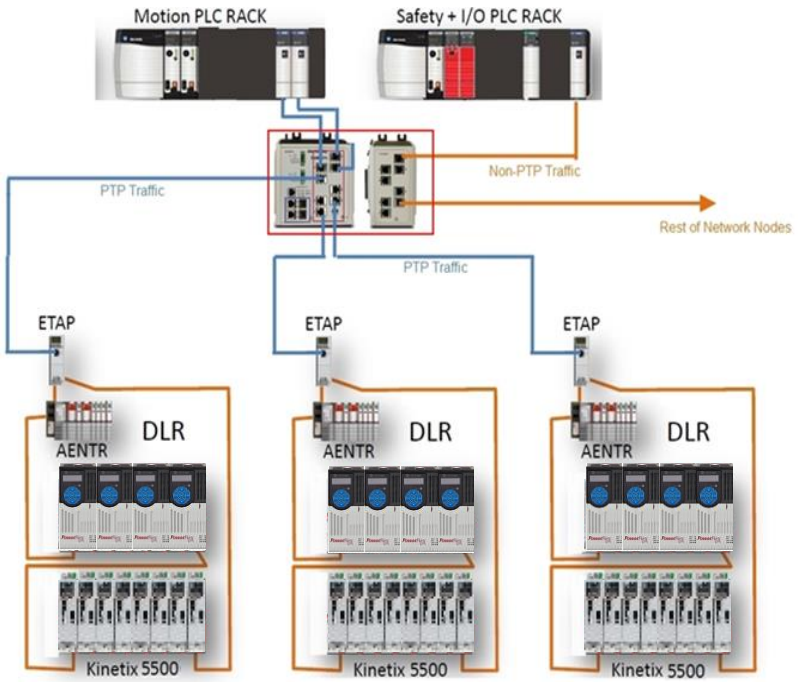
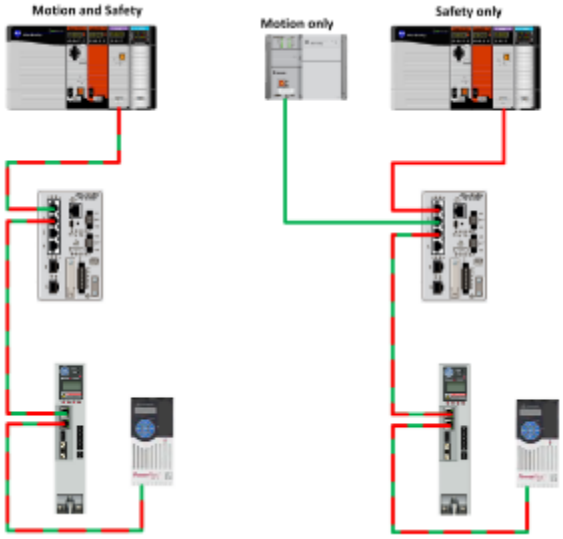
Integrated Safety on EtherNet/IP







Flexibility with standard connection configurations

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Integrated Safety on EtherNet/IP

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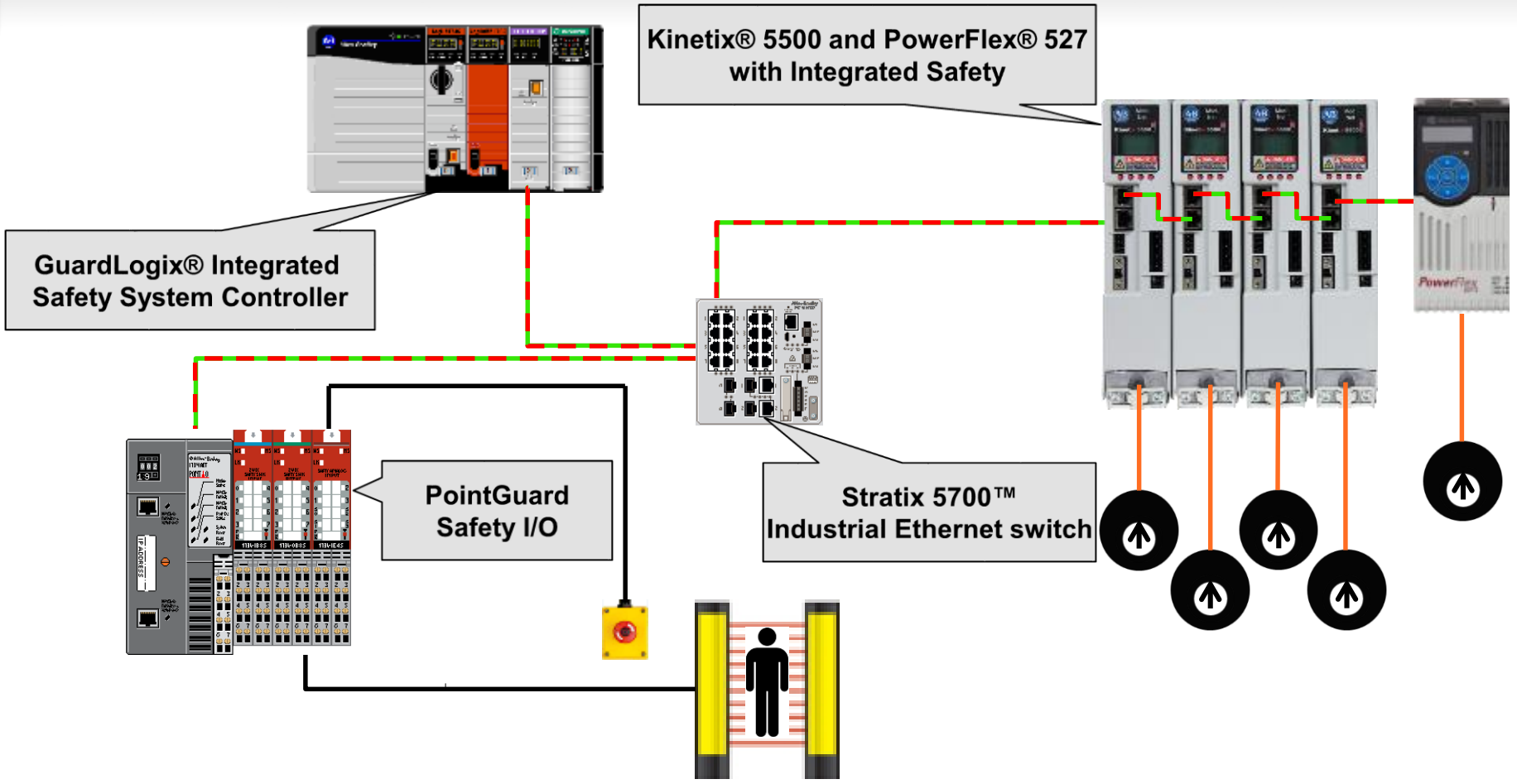
Kinetix® 5500 and PowerFlex® 527 with Integrated Safety
GuardLogix® Integrated Safety System Controller
PointGuard Safety I/O
Stratix 5700™ Industrial Ethernet switch

Integrated Safety Enhances Machine Performance and Flexibility

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Application Example #1:
GuardLogix® for **Safety** and **Motion** Control

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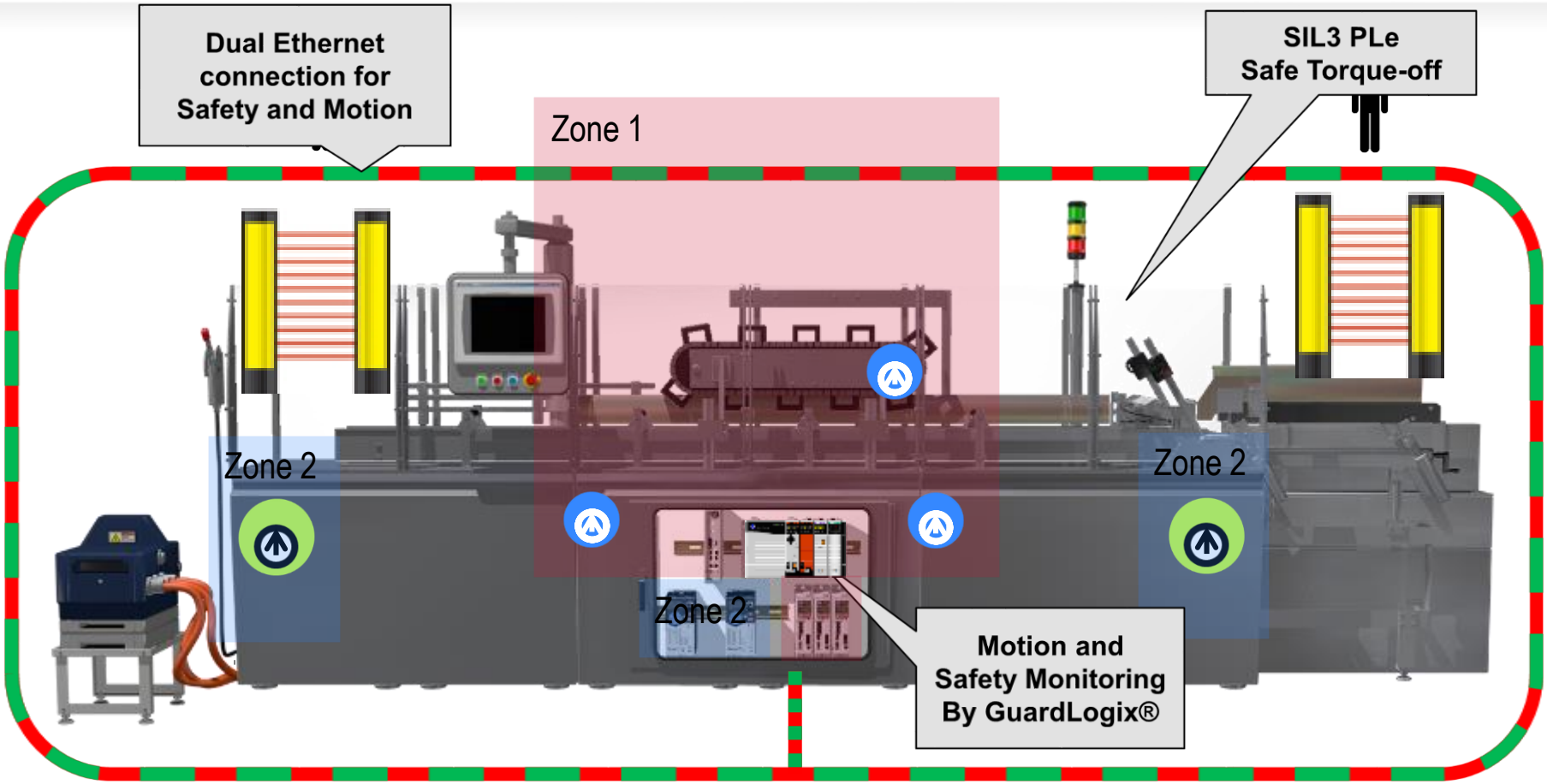

GuardLogix® allows machine flexibility for Motion and Safety

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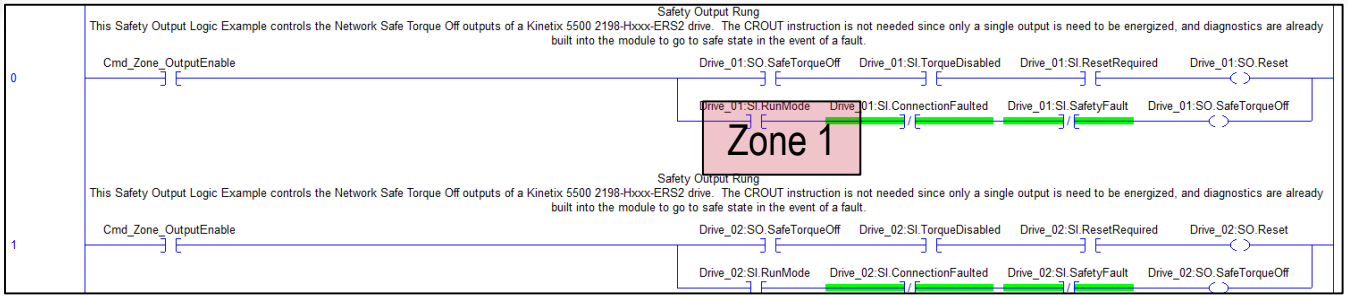
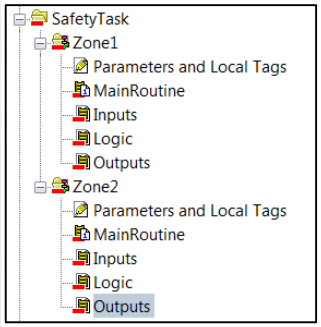
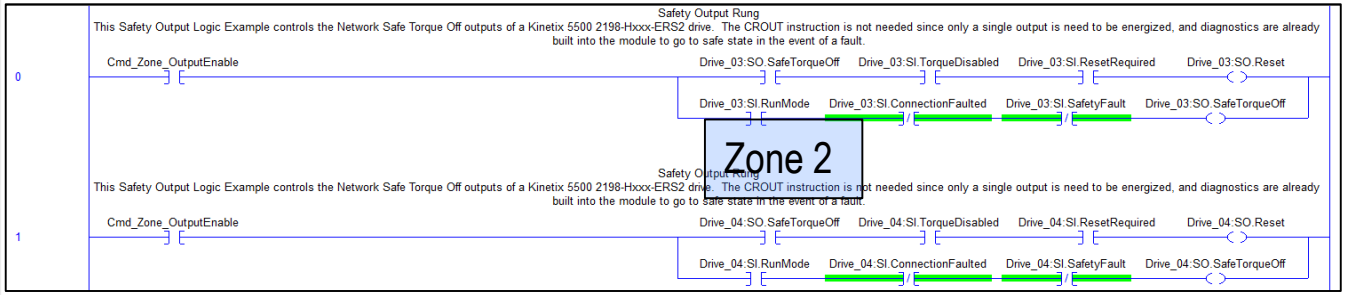
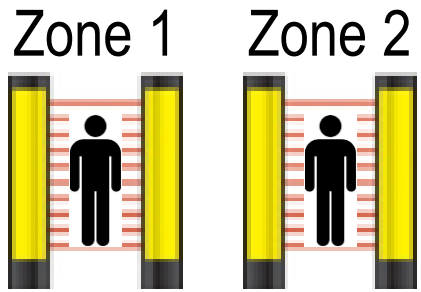
Safety Zoning in Logix Designer


Safety Output Rung
This Safety Output Logic Example controls the Network Safe Torque Off outputs of a Kinetix 5500 2198-Hxxx-ERS2 drive. The CROUT instruction is not needed since only a single output is need to be energized, and diagnostics are already built into the module to go to safe state in the event of a fault.
Cmd_Zone_OutputEnable
Drive_01:SO.SafeTorqueOff
Drive_01:SI.TorqueDisabled
Drive_01:SI.ResetRequired
Drive_01:SO.Reset
Drive_01:SI.RunMode
Drive_01:SI.ConnectionFaulted
Drive_01:SI.SafetyFault
Drive_01:SO.SafeTorqueOff
Zone 1
Safety Output Rung
This Safety Output Logic Example controls the Network Safe Torque Off outputs of a Kinetix 5500 2198-Hxxx-ERS2 drive. The CROUT instruction is not needed since only a single output is need to be energized, and diagnostics are already built into the module to go to safe state in the event of a fault.
Cmd_Zone_OutputEnable
Drive_02:SO.SafeTorqueOff
Drive_02:SI.TorqueDisabled
Drive_02:SI.ResetRequired
Drive_02:SO.Reset
Drive_02:SI.RunMode
Drive_02:SI.ConnectionFaulted
Drive_02:SI.SafetyFault
Drive_02:SO.SafeTorqueOff



- Machine safety is configured in the safety task of Logix Designer.
- Safety connections made through EtherNet/IP.
- No additional wiring is required.


Safety Output Rung
This Safety Output Logic Example controls the Network Safe Torque Off outputs of a Kinetix 5500 2198-Hxxx-ERS2 drive. The CROUT instruction is not needed since only a single output is need to be energized, and diagnostics are already built into the module to go to safe state in the event of a fault.
Cmd_Zone_OutputEnable
Drive_03:SO.SafeTorqueOff
Drive_03:SI.TorqueDisabled
Drive_03:SI.ResetRequired
Drive_03:SO.Reset
Drive_03:SI.RunMode
Drive_03:SI.ConnectionFaulted
Drive_03:SI.SafetyFault
Drive_03:SO.SafeTorqueOff
Zone 2
Safety Output Rung
This Safety Output Logic Example controls the Network Safe Torque Off outputs of a Kinetix 5500 2198-Hxxx-ERS2 drive. The CROUT instruction is not needed since only a single output is need to be energized, and diagnostics are already built into the module to go to safe state in the event of a fault.
Cmd_Zone_OutputEnable
Drive_04:SO.SafeTorqueOff
Drive_04:SI.TorqueDisabled
Drive_04:SI.ResetRequired
Drive_04:SO.Reset
Drive_04:SI.RunMode
Drive_04:SI.ConnectionFaulted
Drive_04:SI.SafetyFault
Drive_04:SO.SafeTorqueOff



Programmatically change the safety zones in Logix Designer

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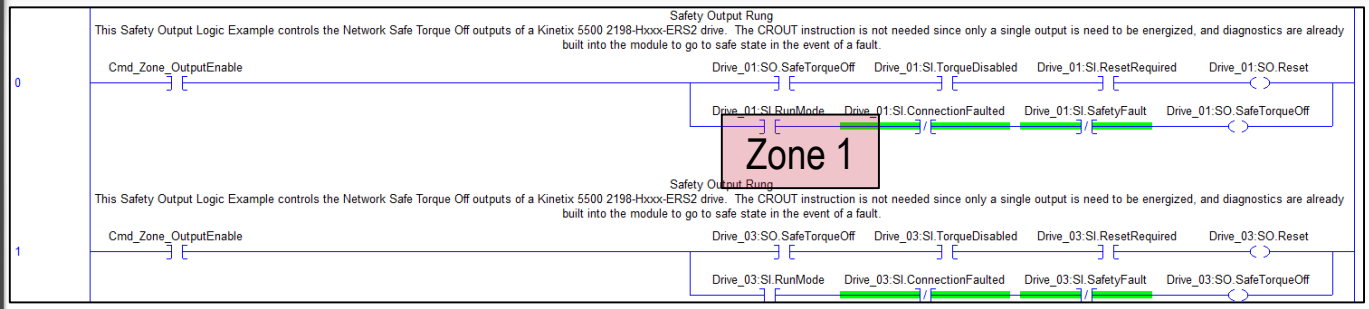
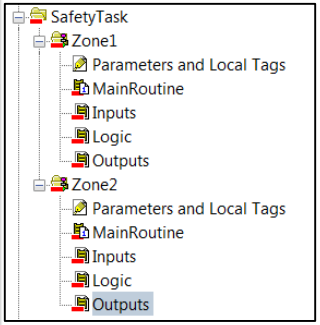
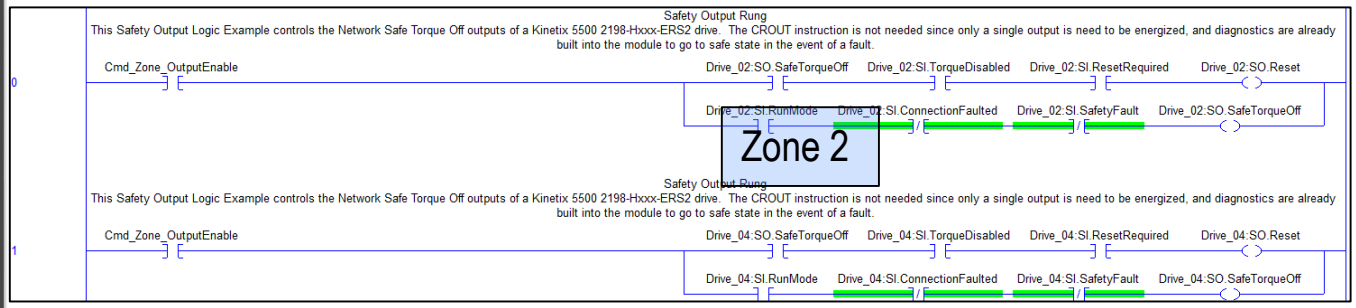
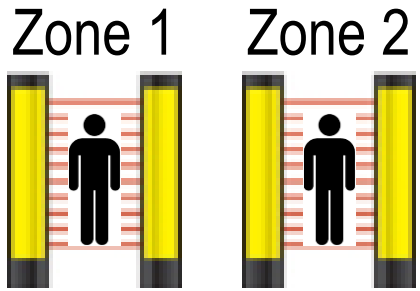
Safety Zoning in Logix Designer


Safety Output Rung
This Safety Output Logic Example controls the Network Safe Torque Off outputs of a Kinetix 5500 2198-Hxxx-ERS2 drive. The CROUT instruction is not needed since only a single output is need to be energized, and diagnostics are already built into the module to go to safe state in the event of a fault.
Cmd_Zone_OutputEnable
Drive_01:SO.SafeTorqueOff
Drive_01:SI.TorqueDisabled
Drive_01:SI.ResetRequired
Drive_01:SO.Reset
Drive_01:SI.RunMode
Drive_01:SI.ConnectionFaulted
Drive_01:SI.SafetyFault
Drive_01:SO.SafeTorqueOff
Zone 1
Safety Output Rung
This Safety Output Logic Example controls the Network Safe Torque Off outputs of a Kinetix 5500 2198-Hxxx-ERS2 drive. The CROUT instruction is not needed since only a single output is need to be energized, and diagnostics are already built into the module to go to safe state in the event of a fault.
Cmd_Zone_OutputEnable
Drive_03:SO.SafeTorqueOff
Drive_03:SI.TorqueDisabled
Drive_03:SI.ResetRequired
Drive_03:SO.Reset
Drive_03:SI.RunMode
Drive_03:SI.ConnectionFaulted
Drive_03:SI.SafetyFault
Drive_03:SO.SafeTorqueOff



- Machine safety is configured in the safety task of Logix Designer.
- *Cut/paste Axis from one zone to another*.
- Safety connection to the drive via EtherNet/IP.
- No additional wiring is required.


Safety Output Rung
This Safety Output Logic Example controls the Network Safe Torque Off outputs of a Kinetix 5500 2198-Hxxx-ERS2 drive. The CROUT instruction is not needed since only a single output is need to be energized, and diagnostics are already built into the module to go to safe state in the event of a fault.
Cmd_Zone_OutputEnable
Drive_02:SO.SafeTorqueOff
Drive_02:SI.TorqueDisabled
Drive_02:SI.ResetRequired
Drive_02:SO.Reset
Drive_02:SI.RunMode
Drive_02:SI.ConnectionFaulted
Drive_02:SI.SafetyFault
Drive_02:SO.SafeTorqueOff
Zone 2
Safety Output Rung
This Safety Output Logic Example controls the Network Safe Torque Off outputs of a Kinetix 5500 2198-Hxxx-ERS2 drive. The CROUT instruction is not needed since only a single output is need to be energized, and diagnostics are already built into the module to go to safe state in the event of a fault.
Cmd_Zone_OutputEnable
Drive_04:SO.SafeTorqueOff
Drive_04:SI.TorqueDisabled
Drive_04:SI.ResetRequired
Drive_04:SO.Reset
Drive_04:SI.RunMode
Drive_04:SI.ConnectionFaulted
Drive_04:SI.SafetyFault
Drive_04:SO.SafeTorqueOff



Programmatically change the safety zones in Logix Designer

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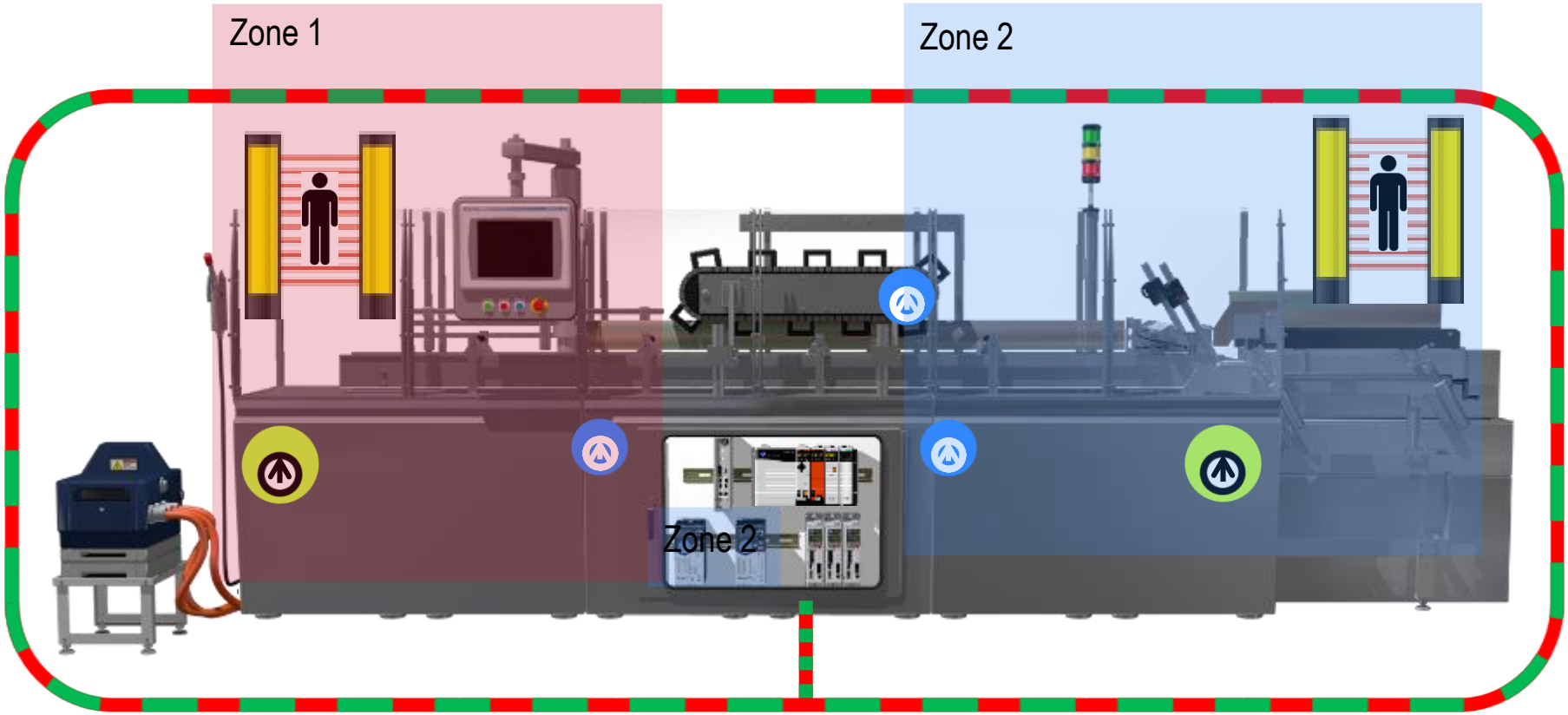
Application Example #1:
GuardLogix® for Safety and Motion Control

Rockwell Automation



Machine flexibility for modular design, configuration and safety zoning

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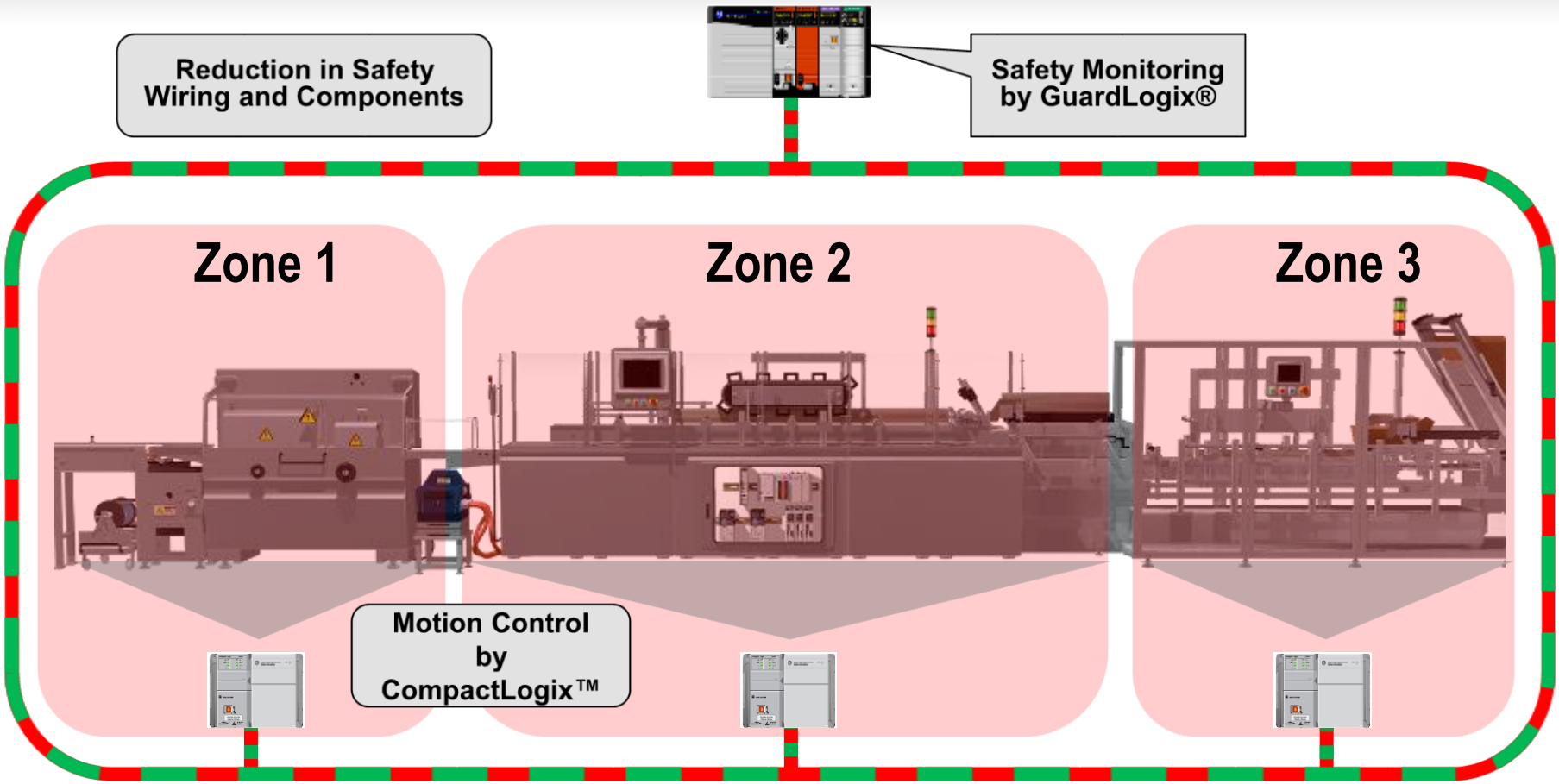
Application Example #2:
GuardLogix® for Safety and CompactLogix™ for Motion

Rockwell Automation



Machine flexibility with separated control for Motion and Safety

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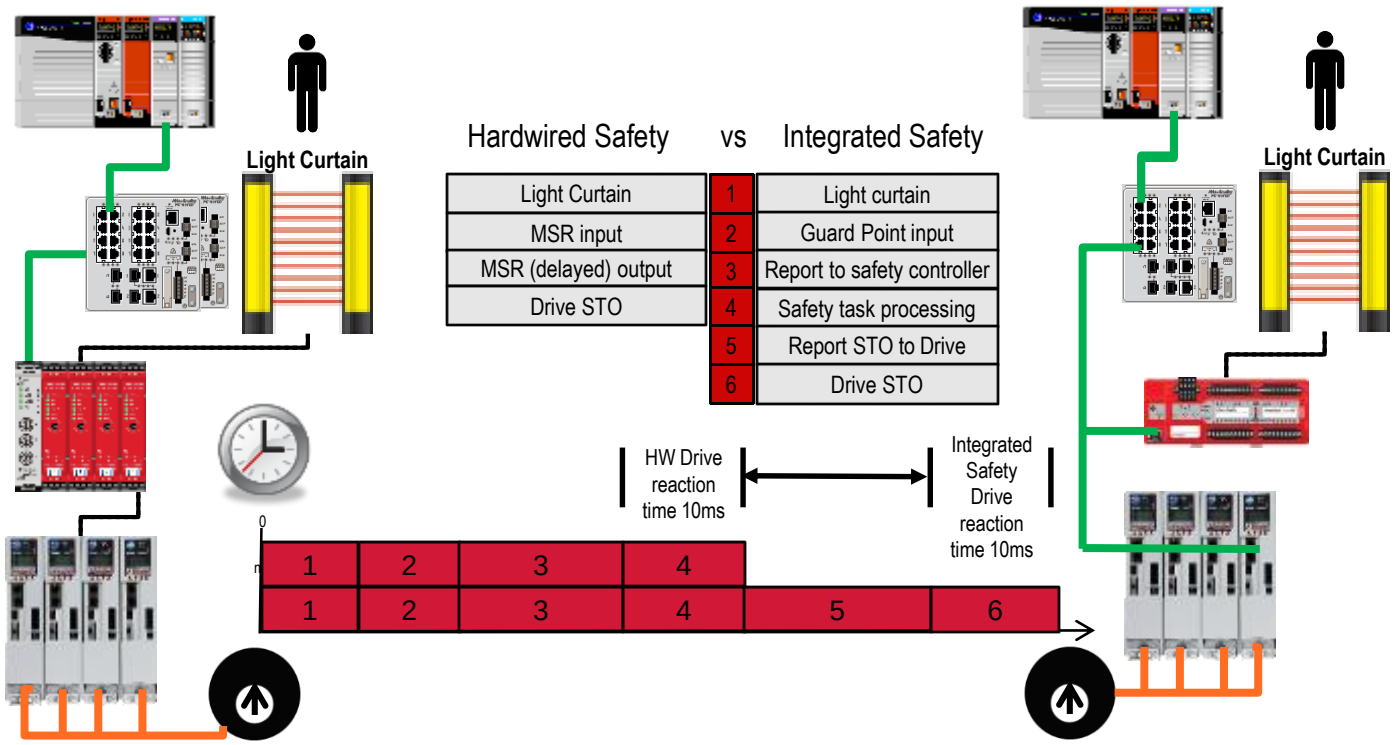
Safety Reaction Time

Explanation



Use Safety reaction time tool to calculate system reaction time.

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Safety Comparison

Drive Based vs Integrated

	Drive Based	Integrated Safety
Configuration	Specific to each device	Unified in controller
Wiring to Drive	Often intensive wiring	Reduced or eliminated
Diagnostics	Limited	Detailed
Integration	Very little controller integration	Seamlessly part of controller
Maintenance	Manual operation for replacement	Automatic device configuration
Application Space	Only for specific problems	Easily customized for anything
Code Validation	Must be repeated every time	Simplified through code re-use

Increasing customer value by integrating safety into the architecture.

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Integrated Safety
Features and Benefits

Rockwell Automation

Reduce System Cost

- Perform SIL3 PLe Safe Torque-off safety functions over EtherNet/IP connection.
- Reduction in wiring of safety circuit.
- Fewer number of components required.
- Safety system validation through code reuse.
- Reduction in cabinet space requirements.

Ease of Use

- Complete project integration in Logix Designer of control, safety and motion.
- Increased flexibility and modularity of system design and safety zoning.
- Detailed diagnostics to assist in commissioning and troubleshooting safety related faults.
- Safety zone configuration change without changing hardware.

Integrated Safety Enhances Machine Performance

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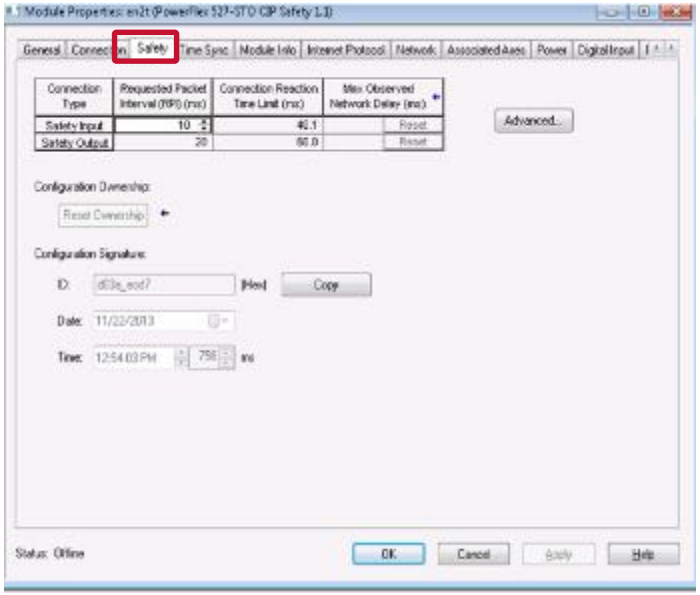
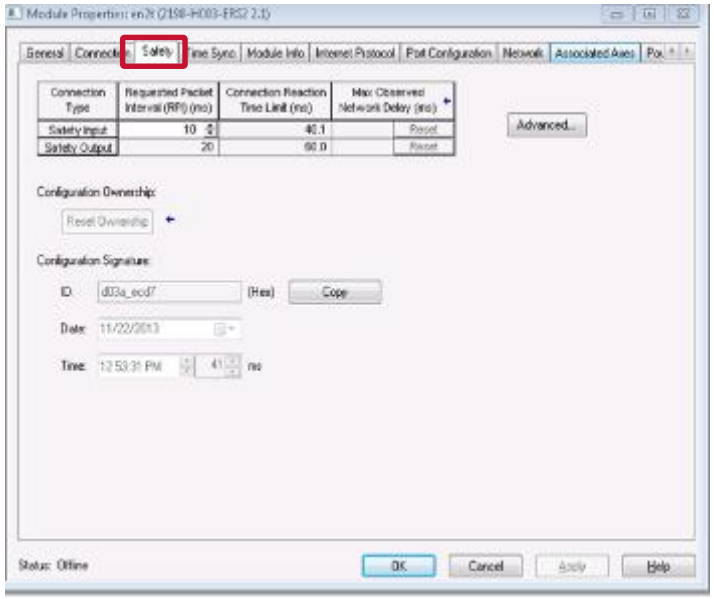
Common User Experience for Safety

Rockwell Automation

PowerFlex® 527



Kinetix® 5500



Integrated Motion and Safety configuration is identical in Logix Designer

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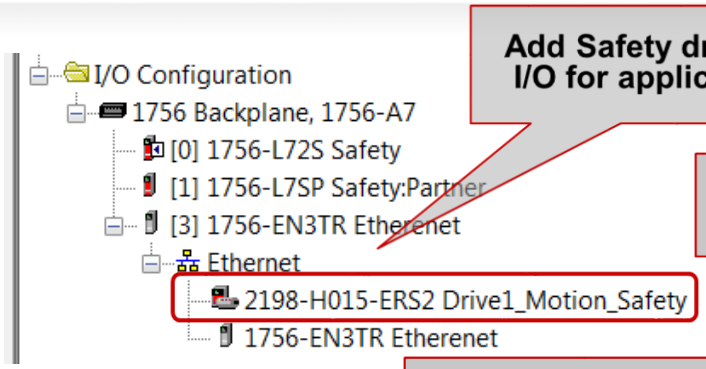
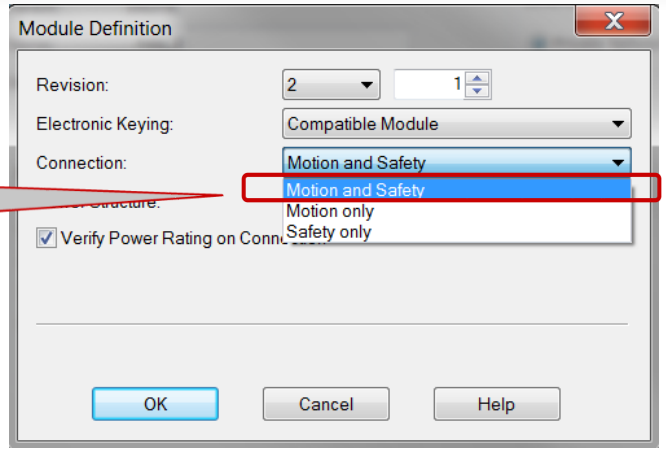
Logix Designer Configuration

Rockwell Automation



Add Safety drive to I/O for application

Select Connection Type



Tag structure created for easy application monitoring

Scope: Safety Show: All Tags

Name	Value	Force Mask	Style	Data Type	Class
Drive1_Motion_Safety:S	{...}	{...}		AB:Motion_Di...	Standard
Drive1_Motion_Safety:SI	{...}	{...}		AB:CIP_Drive...	Safety
Drive1_Motion_Safety:SI.ConnectionStatus	2#0000_...		Binary	DINT	Safety
Drive1_Motion_Safety:SI.RunMode	0		Decimal	BOOL	Safety
Drive1_Motion_Safety:SI.ConnectionFaulted	0		Decimal	BOOL	Safety
Drive1_Motion_Safety:SI.Status	2#0000_...		Binary	SINT	Safety
Drive1_Motion_Safety:SI.TorqueDisabled	0		Decimal	BOOL	Safety
Drive1_Motion_Safety:SI.SafetyFault	0		Decimal	BOOL	Safety
Drive1_Motion_Safety:SI.ResetRequired	0		Decimal	BOOL	Safety
Drive1_Motion_Safety:SO	{...}	{...}		AB:CIP_Drive...	Safety
Drive1_Motion_Safety:SO.Command	2#0000_...		Binary	SINT	Safety
Drive1_Motion_Safety:SO.SafeTorqueOff	0		Decimal	BOOL	Safety
Drive1_Motion_Safety:SO.Reset	0		Decimal	BOOL	Safety

Complete and easy configuration for safety with Logix Designer.

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Safe Torque-off Certification

Kinetix® 5500 and PowerFlex® 527

Rockwell Automation

- **TÜV Rheinland Approved**
  - **Integrated safety with EtherNet/IP**
    - **PLe, CAT3** per ISO 13849-1
    - **SIL3** per IEC EN 61508, EN 62061 and EN 61800-5-2
    - Stop Category 0, EN 60204

Table 3 — Performance levels (PL)

PL	Average probability of dangerous failure per hour 1/h
a	$\geq 10^{-5}$ to $< 10^{-4}$
b	$\geq 3 \times 10^{-6}$ to $< 10^{-5}$
c	$\geq 10^{-6}$ to $< 3 \times 10^{-6}$
d	$\geq 10^{-7}$ to $< 10^{-6}$
e	$\geq 10^{-8}$ to $< 10^{-7}$

NOTE Besides the average probability of dangerous failure per hour other measures are also necessary to achieve the PL.

Increased safety rating using Kinetix® 5500 with Integrated Safety.

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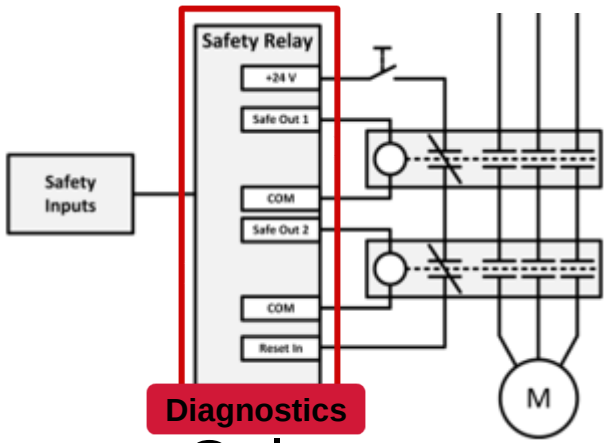
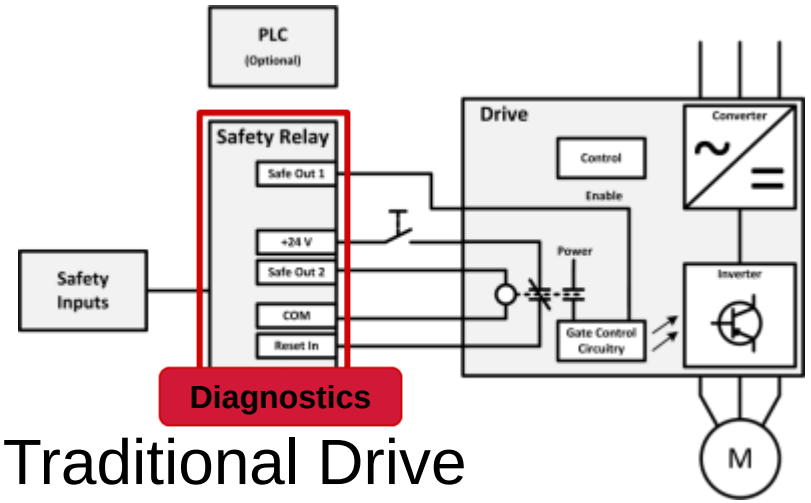
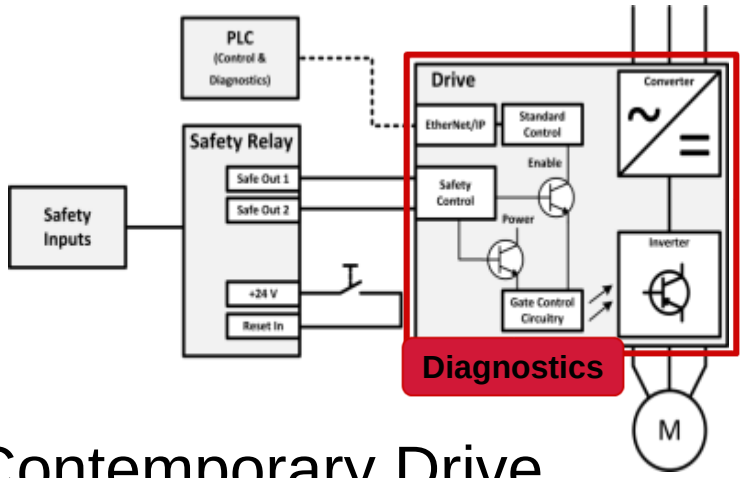
Drive Safety - Diagnostics



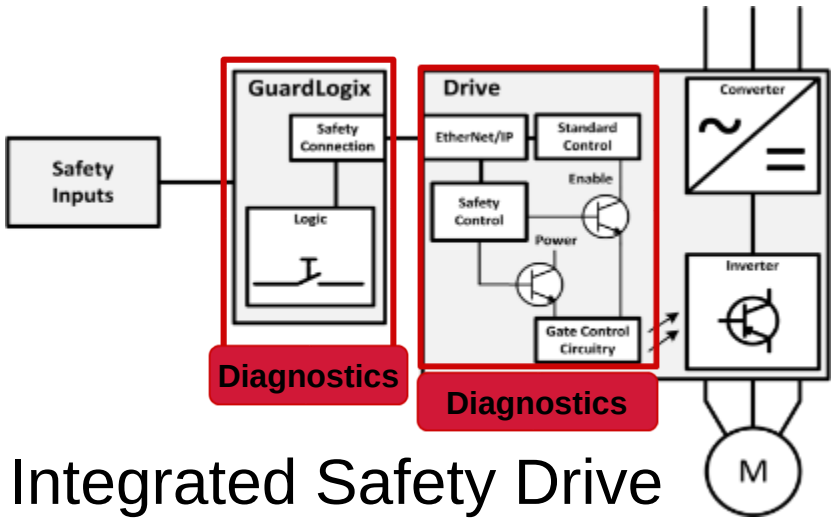
Contactors Only



Traditional Drive



Contemporary Drive



Integrated Safety Drive

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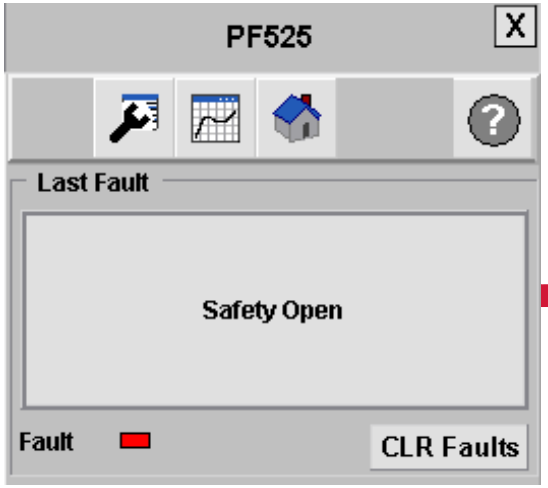
Drive Safety Functions

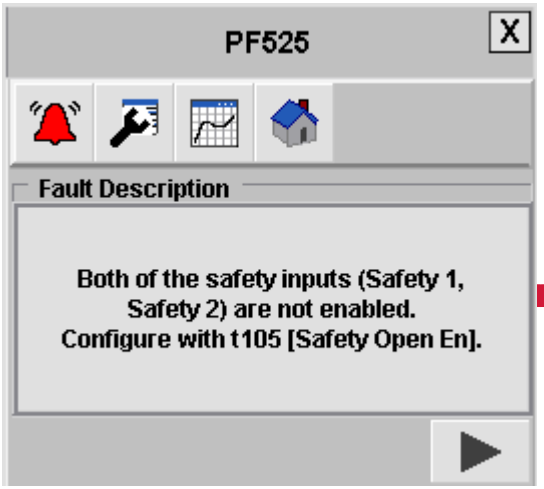
Reset Function & Feedback Circuits

Rockwell Automation

- Network integration gives access to the drive status
- Apply these to Indicator Lights or HMI screens for faster troubleshooting

PF525_Drive:I	{...}
PF525_Drive:I.DriveStatus	2#0000_0000_0000_0000
PF525_Drive:I.Ready	0
PF525_Drive:I.Active	0
PF525_Drive:I.CommandDir	0
PF525_Drive:I.DigIn4Active	0
PF525_Drive:I.OutputFreq	0
PF525_Drive:I.OutputCurrent	0
PF525_Drive:I.DriveStatus_param	2#0000_0000_0000_0000
PF525_Drive:I.DriveStatus_param_Running	0
PF525_Drive:I.DriveStatus_param_Forward	0
PF525_Drive:I.DriveStatus_param_Accelerating	0
PF525_Drive:I.DriveStatus_param_Decelerating	0
PF525_Drive:I.DriveStatus_param_SafetyActive	0





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Agenda

Rockwell Automation

- Introduction
- Machine Safety Lifecycle
- Motor / Drive Safety
- Integrated Safety
- **Tools & Services**

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Rockwell Automation® Safety Tools

Rockwell Automation

Safety Return-On-Investment Tool
Find out how to quantify the savings and productivity gains from safety investments. The Rockwell Automation® Safety Return-On-Investment Tool accounts for improved safety, reduced claims, improved productivity, and other issues unique to safety applications.

Safety Functions

Safety Functions Program
The Safety Functions Program is building block approach to designing safety systems. Each building block has a complete documentation package that includes a description of each safety function, an electrical schematic, a bill of material, a SISTEMA verification calculation and a verification and validation plan.

SAB

Safety Automation Builder
The Safety Automation Builder software package that allows users to import images of their machines. Users can identify hazardous access points and the associated hazards in order to develop a list of safety products that will be used to mitigate the risk. This gives the customer a complete drawing, a bill of material and SISTEMA calculation.

Connected Components BB

Safety Connected Components Building Blocks
The Connected Components Building Blocks provide users with pre-designed safety solutions that have panel drawings, wiring diagrams, programs, HMI screens and start-up manuals make the design and integration of safety systems quick and easy.

Safety Solutions Toolkit

Safety Solutions Toolkit
The Safety Solutions Toolkit is a tool that presents all safety-related product launches, presentations, videos & animations, literature, event archives, and many other additional resources that the Rockwell Automation® Safety Solutions program provides.

Safety Accelerator Toolkit

Safety Accelerator Toolkit
The Safety Accelerator Toolkit provides easy to use system design, programming, and diagnostic tools to assist you in the rapid development and deployment of your safety systems using GuardLogix®, Compact GuardLogix®, or SmartGuard™ 600 Controllers, Guard I/O™, and Safety Devices. The toolkit includes a risk assessment and system design guide, hardware selection guide, CAD drawings, safety logic routines, and operator status and diagnostic faceplates.

Pro-Safe Builder

Pro-Safe Trapped Key Builder
The Pro-safe Trapped Key Builder tool allows you to build safety solutions using a broad range of trapped key switches and devices that can isolate pneumatic, hydraulic and electrical sources in a systematic repeatable process. Pro-safe builder is linked to ProposalWorks™ to allow users to generate complete Bills of Materials (BOM).

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Safety Function Library

Overview

- "Building Blocks" approach to safety
- Combine blocks together for more complex functions
- Available for GuardLogix® controller or GuardMaster relay solutions
- Each one includes:
  - System descriptions of operations
  - Parts lists
  - Electrical drawings
  - SISTEMA calculations
  - Verification & Validation plans

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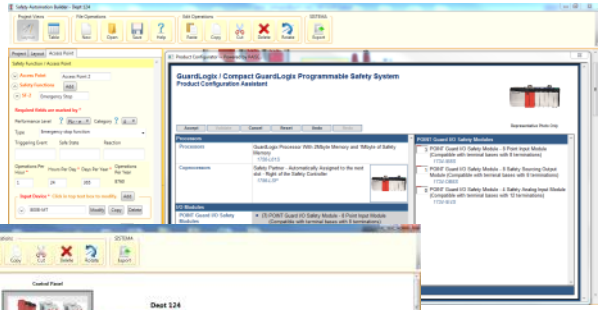
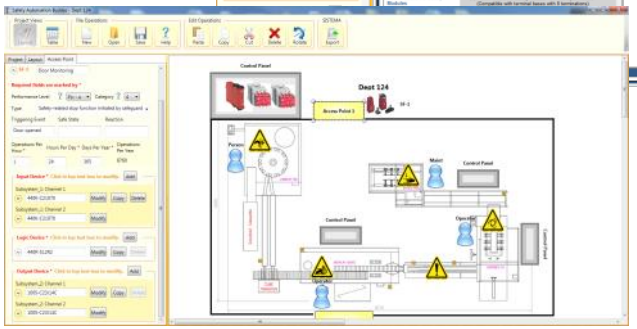
Safety Automation Builder

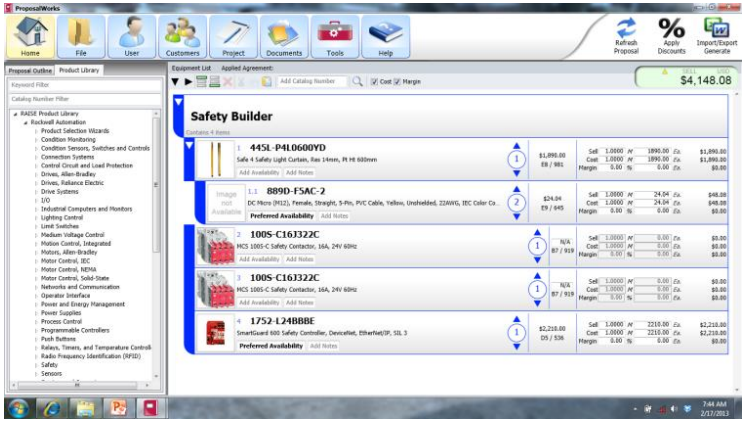
Overview

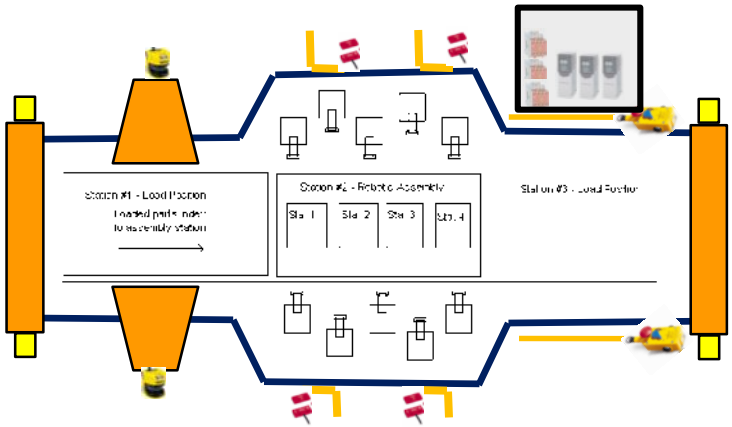
- Use Safety Automation Builder to:
  - Layout machine hazards and access points
  - Define safety functions and select safety products
  - Export data to SISTEMA for analysis*
- Outputs of Safety Automation Builder include:
  - Bill of Material
  - Conceptual safety layout drawings
  - SISTEMA project files*





** Safety Automation Builder and SISTEMA tools must be used in conjunction with each other to provide this output*





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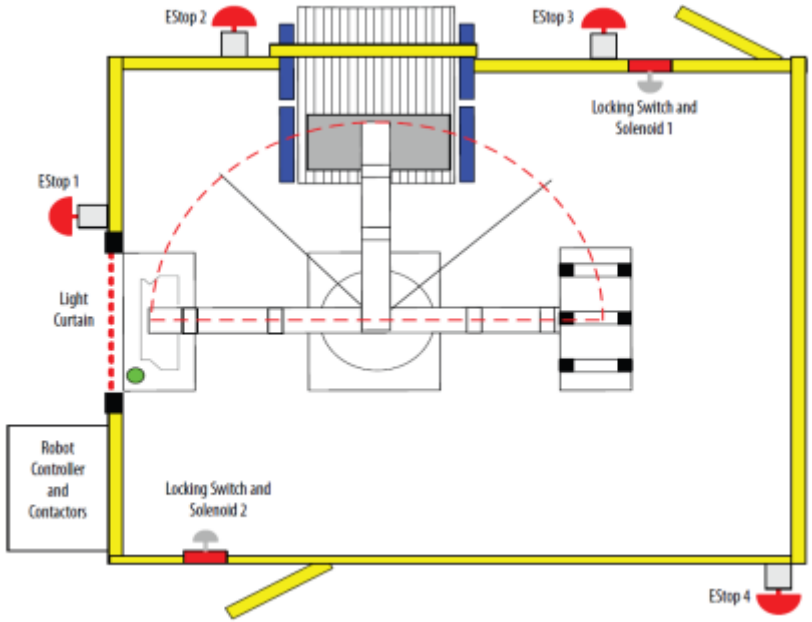
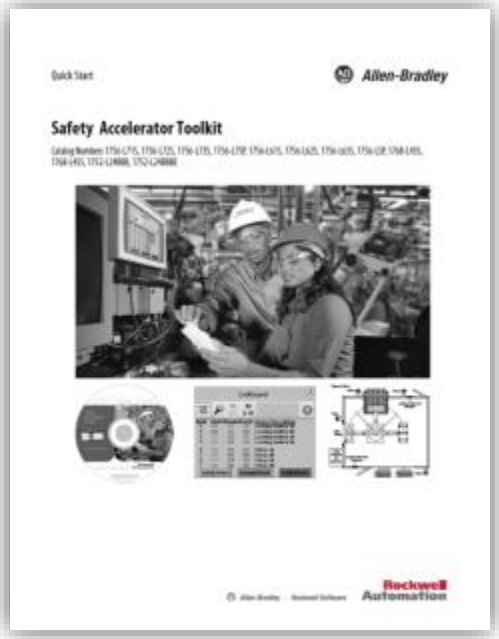
Safety Accelerator Toolkit

Overview

- Details the integration of multiple safety functions
- Includes importable wiring diagrams, logic, and HMI files
- Designed for use with programmable safety controllers, such as GuardLogix® and SmartGuard™ 600
- Available on DVD or as a download from the web





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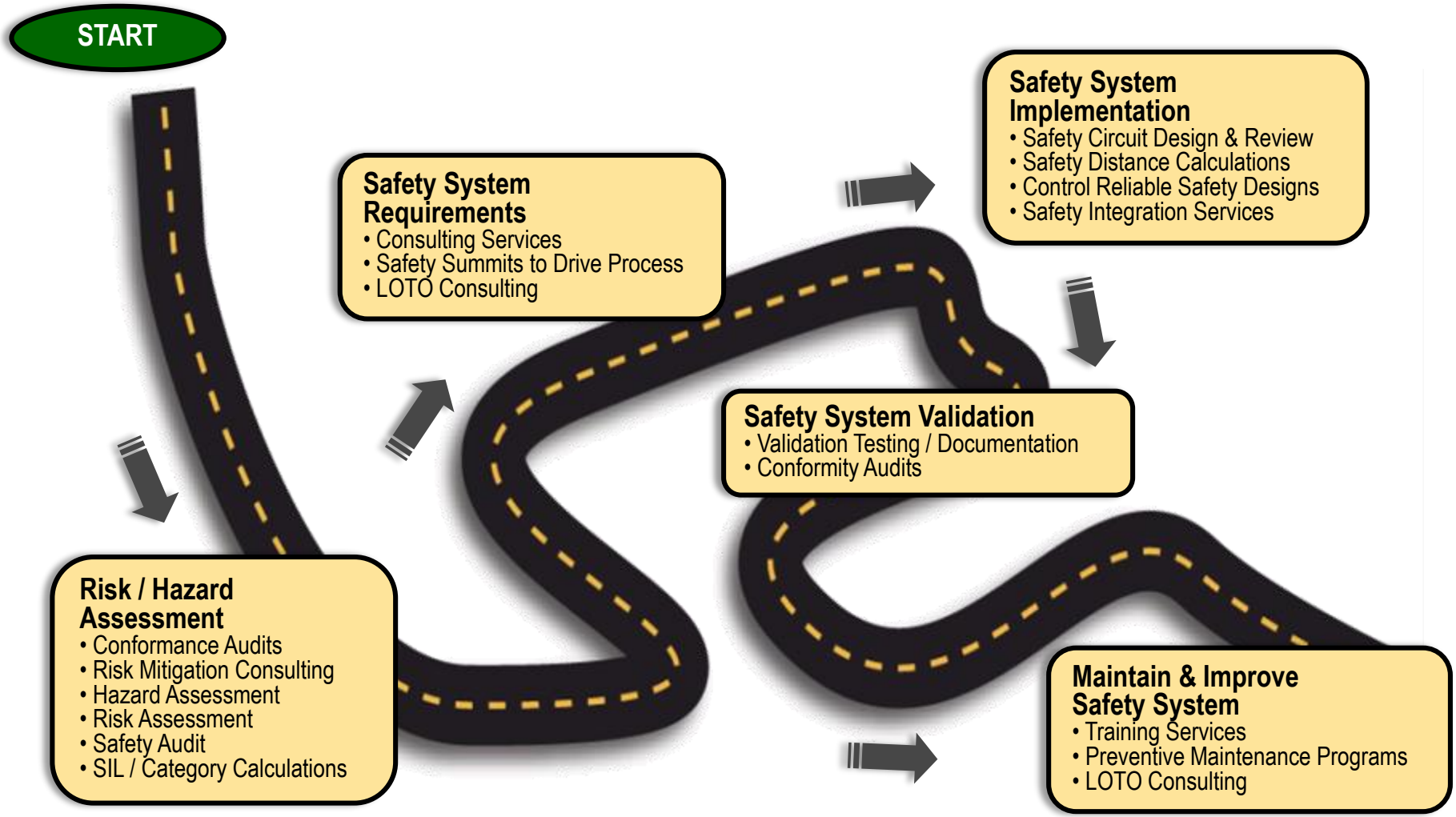
Rockwell Automation® Safety Services



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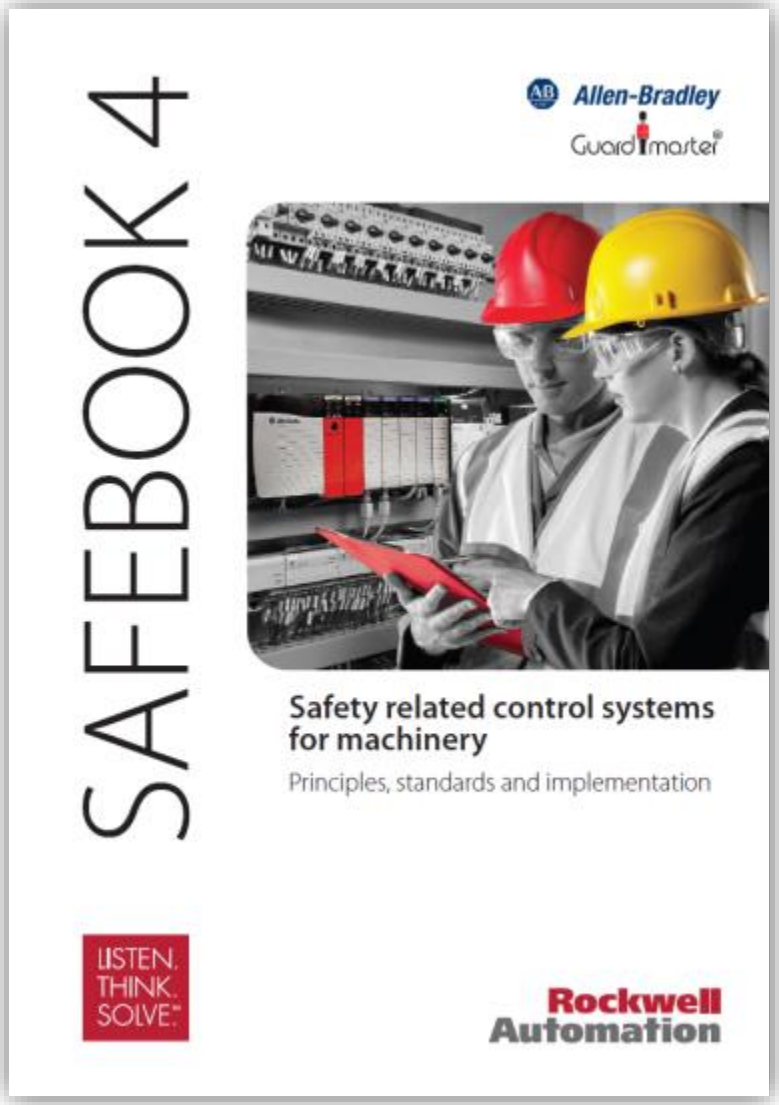
Safebook 4



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Machine Safety Resources

- ANSI – American National Standards Institute
  - www.ansi.org
- Explanation and Interpretation of Standards from Rockwell Automation®
  - www.ab.com
    - → Product Catalogs → Safety Products → Principles, Standards and Implementation → Standards
- Information on Rockwell Automation® Safety Solutions and Services
  - www.rockwellautomation.com
    - → Solutions & Services → Safety Solutions
- Safety Functions, User Manuals, Safebook 4, and more…
  - literature.rockwellautomation.com

Talk to Your Distributor Specialists and Rockwell Automation® Specialists!

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